GEVAERT

MANUAL OF PHOTOGRAPHY

A. H. S. CRAEYBECKX

GEVAERT MANUAL OF PHOTOGRAPHY

A practical guide for professionals
and advanced amateurs

Translated by
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PREFACE

This is the fifth English edition of the Gevaert Manual. The Manual has been published over a period of years in a dozen different languages during which time the work has been constantly revised so that today it is an entirely different book. It has become a complete treatise on photography, and is addressed to workers who wish to acquire a thoroughly practical and technical knowledge of the subject to enable them to practise photography with understanding. The reader is not involved in deep scientific explanations.

Some of the text is printed in smaller type, these being passages which need not at first be read. However, the additional details comprised in them may be of interest and help. Furthermore, a classified bibliography is included and it is hoped that this selection of works published in the English language will enable the reader to pursue specialized subjects.

The author desires to express his grateful thanks to his colleagues and collaborators who have helped in keeping the editions of the Gevaert Manual up to date. He wishes to mention especially P. Luyten, who has studied the water-treatment of emulsions, A. A. Van Uffelen on retouching, J. Lauwers on colour photography, J. Welffens on transparencies, and P. Germeys on darkroom equipment and technique.

He would also very much like to thank Mr C. J. Duncan, not only for his translation, but for the various suggestions he made, many of which have enriched the text.

Finally, the author must point out that as a number of the products mentioned in this Manual are not obtainable in all countries the reader is advised to consult his photographic dealer.

It is hoped that this new and considerably enlarged edition, which has been produced by the Fountain Press, will be received with the same welcome as were the previous editions.

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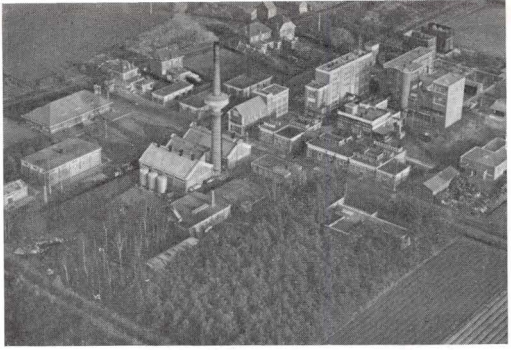
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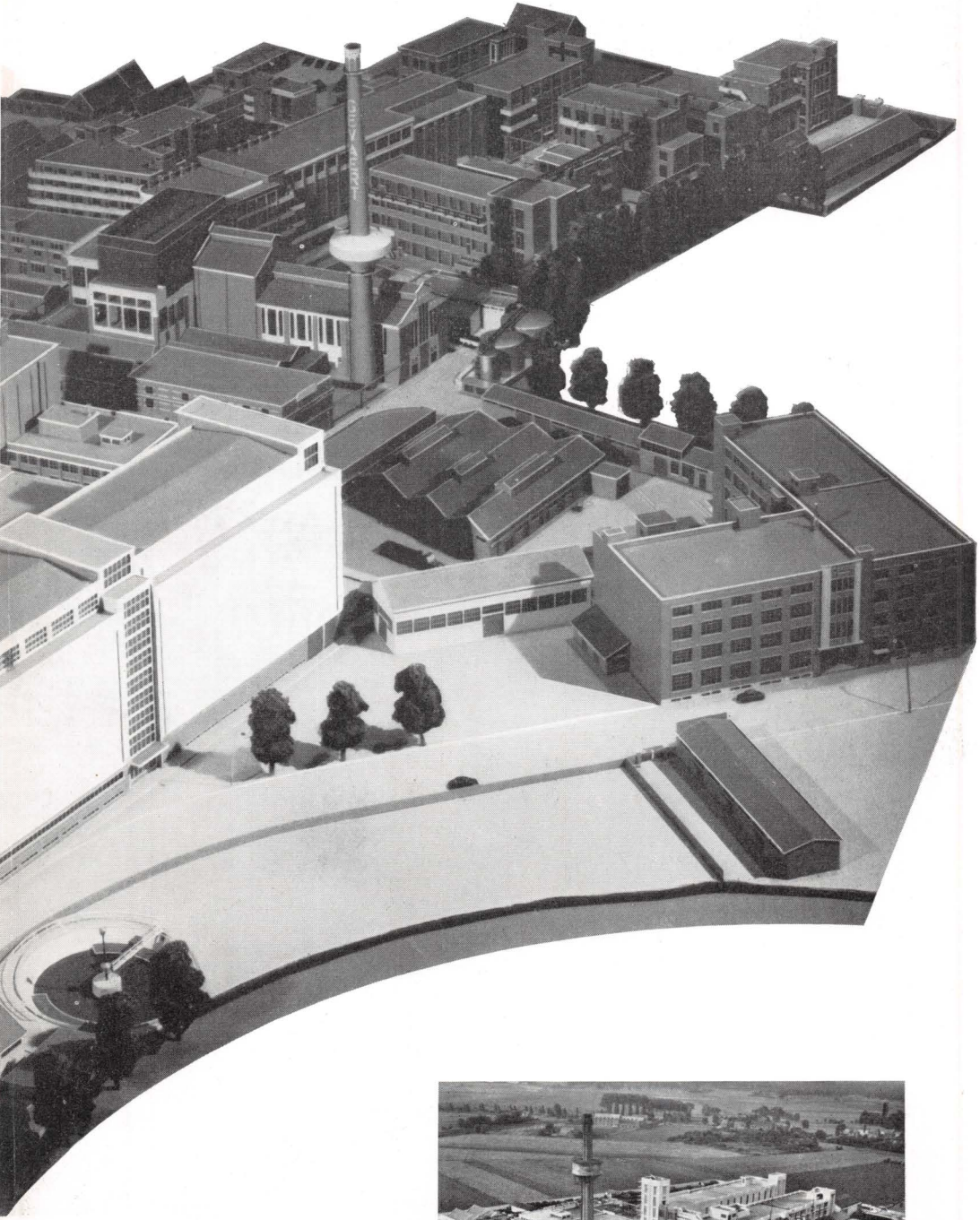
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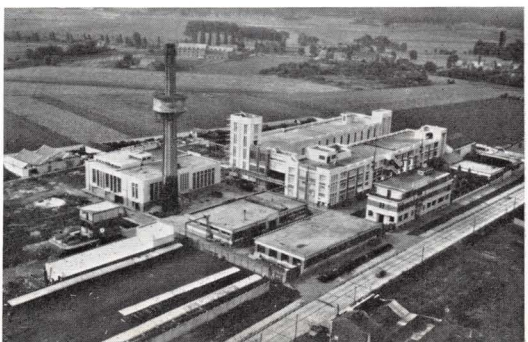
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Model of the Gevaert Factories at Mortsel, Antwerp, Belgium. At the top left corner the factories at Heultje (Belgium), where the cellulose-acetate is made ready for manufacturing the film base. At the bottom right corner, the factories at Pont-à-Marcq (France).



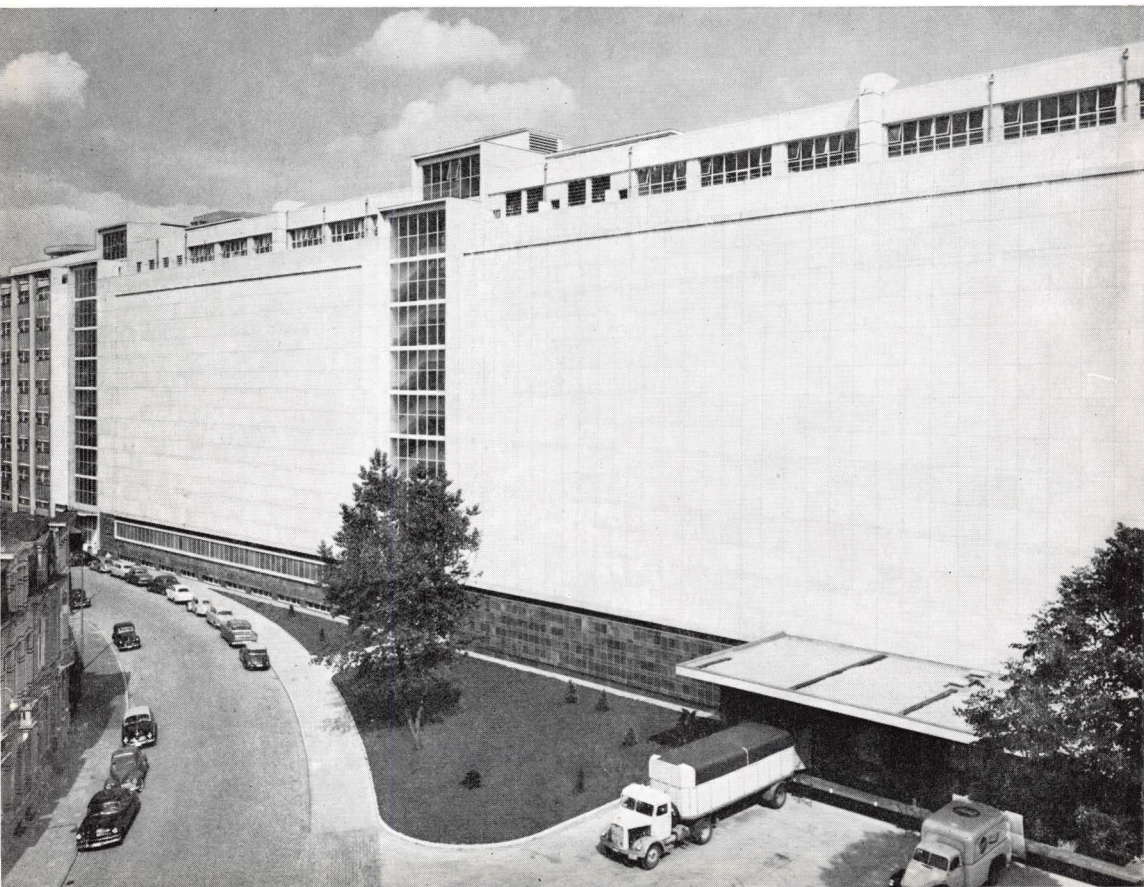


THE GEVAERT FACTORIES

Several miles south of Antwerp, alongside the busy main motor road which leads to the Belgian capital, lies the large group of buildings of the Gevaert factories. The massive buildings, five, six or eight storeys high, and the tall factory chimneys, symbols of work and power, instantly remind the onlooker of his local photographic dealer's shop where the Gevaert trade mark, known and respected all over the world, is displayed over the shop front and in the shop window.

It was over sixty years ago (1894) that Lieven Gevaert, the eminent founder of the firm which bears his name, started his first coating plant for photographic papers in the Anselmo street at Antwerp. Although Lieven Gevaert had already to his credit a number of outstanding inventions, from this small beginning grew the manufacture of photo-sensitive materials.

The establishment of a public company (1895), the acquisition of a considerable area of land at Mortsel, the building of the Gevaert factories there, various





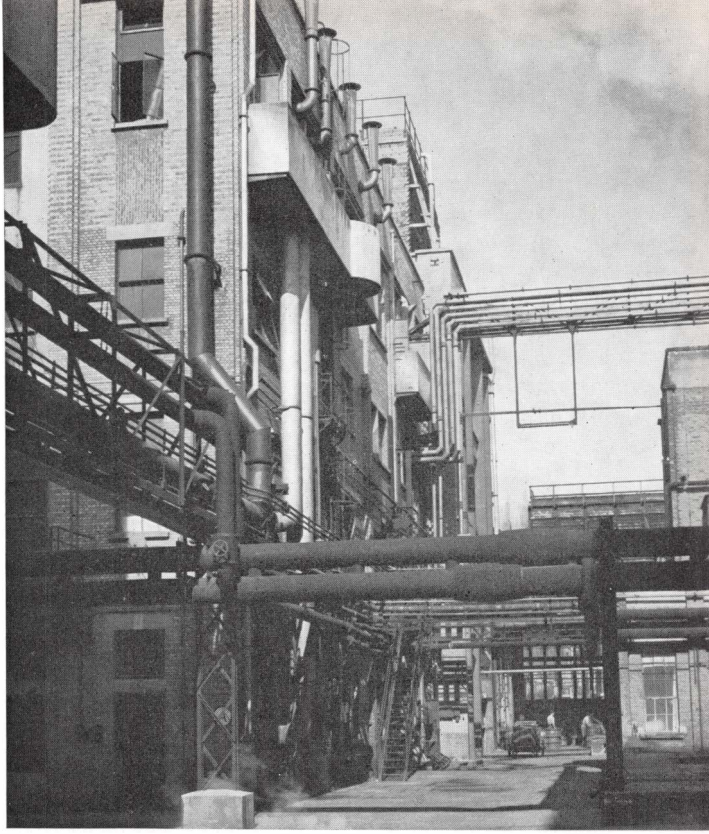
LIEVEN GEVAERT

Founder of the firm Gevaert

There is probably no other industry that calls for so much care as does the manufacture of materials sensitive to light. Temperature, atmospheric pressure, the purity and humidity of the air as well as the purity of the water are all factors of the greatest importance.

A mass of pipes and conduits supplies each of the departments of the Gevaert factory with air, water and power, just as the arteries and veins carry the life blood to all parts of the human body.

The rigorous control of all these factors of manufacture is the guarantee of the good quality and stability of Gevaert products.



expansions in the invested capital, the construction of new factories, the taking-on of several thousand new workpeople, the construction of a special factory east of Antwerp at Heultje for the manufacture of chemical raw materials, all followed as a logical consequence of the rapid and astonishing expansion of the Gevaert enterprise.

The humble workshop where Lieven Gevaert himself worked at his machine is now surrounded by a harmonious group of model factory buildings in which the most up-to-date machines are operated in the most expert and efficient manner by extremely skilled and highly specialized personnel.

The Gevaert factories at Mortsel cover an actual area of nearly 30 acres. More than 8,500 specialists, engineers, chemists staff and operators work here. The chemical factory at Heultje covers an area of 50 acres.

It would take too long to describe in detail the many different processes involved in making the various Gevaert products. In the fantastic world of modern photography, where by the feeble illumination of red or green lamps, thousands of busy hands carry on their work, even the air cannot enter until it has been cleaned and heated or cooled in special plants.

A glance at the photograph of the model will convey an idea of the size of the Gevaert factories, of the long buildings evolved for the coating and packing of films, plates and papers, the modern laboratories for research and for quality

control, the various workshops: engineering, joinery, box-making, machine shops, and so on.

The progressive industrialization of the manufacture of photo-sensitive materials has little by little freed photography from empiricism (hit and miss methods) and brought it increasingly into direct contact with modern scientific method control. Here the most complex properties of silver halide emulsions are being studied systematically and uninterruptedly.

These investigations have resulted in remarkable advances. Using the knowledge so acquired it is possible to prepare emulsions of standardized and constant characteristics. Patient and systematic investigations have succeeded in continuously improving emulsions and in producing materials endowed with completely novel properties, such as, for example, sensitivity to red and infra-red radiation. Careful standardization of emulsion properties not only allows large-scale manufacture but also makes it possible for the user to reproduce exactly any particular method of work which he has previously used successfully, so speeding up his operations and helping him to improve his quality considerably.

Each new scientific or technical application of photography makes it necessary for one or other of the properties of the material to be changed often in a way which is incompatible with another property – a higher overall sensitivity, a colour sensitivity corresponding to that of the eye, or perhaps a maximum sensitivity for a selected range of wavelengths in the visible or invisible; extremely fine grain, a high resolving power, contrast or 'gamma' which may vary from ·5 to 10·0 according to circumstances, etc.; all these are asked for.

As a result of all this, sensitive materials have been developed that are suitable for each particular application and the variety of choice available is very considerable. As well as materials used for ordinary photographic work, as described in this Manual, the Gevaert laboratories have made or are experimenting with many special emulsions for use in science and industry.

Thanks to the development of new manufacturing processes which have had an almost revolutionary effect on the various branches of the work, science is now being served by photography in practically every field of endeavour: medicine, analysis of materials, advertising, journalism, micro-photography, industrial photography, astronomy and innumerable other applications.

So it is that scientific investigations carried out year by year in the laboratories have helped to place photography completely at the service of modern society – to the enrichment of science and the arts, token of a future progress that nothing can halt.

The Wide Network of Branches and Representatives of the

GEVAERT PHOTO-PRODUCTEN N.V.
MORTSEL — ANTWERP — BELGIUM

Aden
United Commercial Agencies, Crater - Aden.

Algeria
Gevaert-France S.A., Algiers.

Angola
Sociedade Comercial Luso - Holandesa Lda., 'Lusolanda', Lisbon.

Argentina
Gevaert Argentina S.A. de Productos Fotográficos, Buenos Aires.

Aruba
Oranjestad Agencies, Oranjestad.

Australia
Harvin Film Laboratory, Marrickville (N.S.W.).
Commonwealth Filmcraft Laboratories Pty. Ltd., Camperdown - Sydney (N.S.W.).

Austria
Photo- und Kamera Vertriebsges. m.b.H., Vienna.

Bahrein
Smart Studio, Bahrein.

Barbados
J. B. Leslie & Co. Ltd., Bridgetown.

Bolivia
La Papelera S.A., La Paz.

Borneo
North Borneo Trading Co. Ltd., Jesselton/North Borneo.

Brazil
Foto Produtos Gevaert do Brasil S.A., Rio de Janeiro.

Burma
Bryan Smith & Co., Rangoon.

Cambodia
Sté Havraise Indochinoise S.A., Phnom-Penh.

Cameroons
Sté J. Fournier & Cie., Yaoundé.

Canada
Photo Importing Agencies Ltd., Toronto.

Cape Verde (Islands)
Casa do Leâo, S. Vicente de Cabo Verde.

Ceylon
Chitrafoto, Colombo.

Chile
Mario Vargas Rosas, Santiago de Chile.
Philips Chilena S.A., Santiago de Chile.

Colombia
Casa Belga Verswijvel & Co., Bogotá.

Congo (Brazzaville) (Republic of -)
S.E.D.A.C., Dolisie.

Congo (Leopoldville) (Republic of -)
Socophar, Brussels.

Costa Rica
Trejos Hermanos, San José.

Cuba
Cubana de Rayos-X y Foto S.A., Havana.

Cyprus
Photographic Products Agencies - Soteriades, Nicosia.

Denmark
Gevaert A/S, Copenhagen.

Dominican Republic
Daniel Espinal C. por A., Santiago de los Caballeros.

Ecuador
Opticum Katz, Quito.
Ecuador Overseas Agencies C.A., Guayaquil.

El Salvador
Egon Westerhausen, San Salvador.

Eritrea
Fotocelere, Asmara.

Ethiopia
Y.K. Tchorbadjian ≪Ethio-Photo≫, Addis-Ababa.
Artistic Printing Press, Addis-Ababa.
Philips Ethiopia (Priv. Ltd. Co.), Addis-Ababa.

Finland
Foto - Nyblin A.B., Helsinki.
Kirjatarvike Oy, Helsinki.
Christian Nissen, Helsinki.
Röntgentekno Oy, Helsinki.

Formosa
see Taiwan.

France
Gevaert-France S.A., Paris.

Germany
Gevaert-Technik Vertriebsgesellschaft m.b.H., Brunswick.

Ghana
Roura & Forgas Ltd., London.
Atlas Company Ltd., Accra.

Gibraltar
Menahem Serruya (1953) Ltd., Gibraltar.

Goa
Cosme Matias Menezes Ltd., Cidade de Goa.

Gozo
see Malta.

Great Britain
Gevaert Limited, Brentford, Middlesex.

Greece
Mme Hélène D. Carra, Athens.

Guatemala
P. H. Stixrud, Guatemala-City.
Philips de Guatemala S.A., Guatemala-City.

Guiana (British -)
Alta-Photo-Studio-and-Store, Georgetown.

Guinea (Portuguese -)
António Pinto, Bissau.

Haiti
Photo S. Kahn, Port-au-Prince.

Holland
N. V. Handelsonderneming Gevaert, The Hague.

Honduras
Pedro Montañola, Tegucigalpa D.C.

Honduras (British -)
Regino Majarrez, Belize.

Hongkong
Hongkong Canton Export Co., Ltd., Hong Kong.

Iceland
Sveinn Björnsson & Co., Reykjavik.

India
Allied Photographics Ltd., Bombay.
Patel India Private Ltd., Bombay.

Indonesia
N.V. Karta, Djakarta.
N.V. Aloen, Djakarta.
Djuara Limited, Djakarta.
P.N. Fadjar Bhakti, Djakarta.

Iran
MIC Co., Ltd., Teheran.
Siemens Iran A.G., Teheran.

Iraq
S. M. Garibian & Co., WLL., Bagdad.

Ireland (Eire)
Gevaert Eire Ltd., Dublin.

Italy
Fotoprodotti Gevaert S.p.A., Milan.

Jamaica (B.W.I.)
The Hercules Agencies Ltd., Kingston.

Japan
Aichi Sangyo K.K., Tokio.
Nagase & Co. Ltd., Osaka.

Jordan
Khalil Fattal & Sons (Jordan) Ltd., Amman.

Katar
Salam Studio & Stores, Doha - Katar.

Kenya & Uganda
E. Robson Ltd., Nairobi.
Twentsche Overseas Trading Co., Ltd., Nairobi.
Lindeteves (Africa) Ltd., Nairobi.

Korea
European Korean Agency, Seoul.

Kuwait
Studio Paramount, Kuwait.

Lebanon
Khalil Fattal & Fils, Beyrouth.

Libya
Michele & Bruno Tascone, Tripoli.

Madagascar
Ets. Dulong de Rosnay, Tananarive.

Madeira
J. G. da Silva Lda., Funchal.

Malaya and Singapore
Maclaine Watson (Imports) Limited, Singapore.

Malta and Gozo
Attard & Co., Valletta.

Mauritius
Mimosa Studio, Port-Louis.

Mexico
Servicio para Artes Gráficas S.A., Mexico.
Siemens Mexicana S.A., Mexico.

Morocco
Mopes, Tetuan.

Mozambique
Octávio R. Lobo Lda., Lourenço Marques.

New Zealand
New Zealand Distributors Ltd., Auckland.

Nicaragua
C. y R. Rivas Opstaele, Cia Ltda., Managua.

Nigeria
Roura & Forgas Ltd., London.
Atlas Nigeria Ltd., Lagos.

Norway
Magnus Böysen & Co., A.S., Oslo.
Gjestvangs Grafiske Fagforretning A.S., Oslo.
Medisinsk Röntgen, Oslo.

Nyassaland
see Rhodesia.

Oman-Muscat-Trucial Coast
Regal Traders, Dubai.
C. Jayant Bros., Muscat.

Pakistan
Allied Photographics (Pakistan) Ltd., Karachi.

Panamá
Siemens Electromédica de Panamá, Panamá.

Paraguay
Foto Solt, Asunción.

Peru
Importaciones Americanas S.A., Lima.
Sadolin & Stimman, S.A. Lima.

Philippines
Oceanic Medical Inc., Manila.

Portugal
Garcez Lda., Lisbon.
Nacional Filmes Lda., Lisbon.

Rhodesia and Nyassaland
Fa. Cinephot (PVT), Ltd., Salisbury.

Rio Muni
Alvaro Miralles Conesa, Bata.

Rwanda-Burundi
Socophar, Brussels.

Sarawak
William Jacks & Co. (M) Ltd., Kuching

Saudi-Arabia
Helmi Faisal, Jeddah.
Abdulrehman Algosaibi General Trading Bureau, Riyadh.

Senegal
J. Hobeika, Dakar.

Sierra Leone
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Singapore
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Geo Djerdjian & Sons, Khartoum.

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J. F. D. Haenen N.V., Paramaribo.

Sweden
Gevaert Svenska AB., Stockholm.

Switzerland
Gevaert-Photo A.G., Basle.

Syria
Khalil Fattal et Fils, Damascus.

Taiwan (Formosa)
Ong Chong Importers and Exporters, Taipei.

Tanganyika
A. C. Gomes & Son, Dar-es-Salaam.

Thailand
N.V. Internationale Crediet- en Handelsvereeniging 'Rotterdam', Rotterdam.
Rotraco Thailand Ltd., Bangkok.

Trinidad
Smith, Robertson and Co. Ltd., Port of Spain.

Tunisia
Gevaert-France S.A., Tunis.

Turkey
Pedrelli Ticaret T.A.O., Galata-Istanbul.

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see Kenya.

Uruguay
Sociedad Anónima Sacir, Montevideo.

U.S.A.
The Gevaert Company of America, Inc., New York.

Venezuela
Micron C.A., Caracas.

Vietnam
J. M. Mohamed Ismaël Fils Aziz & Co., Saïgon.

Yugoslavia
Vibétra S.A., Brussels.

Zanzibar
T. H. Adamjee, Zanzibar.

A LIST OF GEVAERT PRODUCTS

The Gevaert factories make every type of sensitive material for photographic and cinematographic work:

- *films and plates* for the professional and amateur: roll films, miniature films, sheet films. Colour films 'Gevacolor Negative' and 'Gevacolor Reversal';
- *films, plates and papers* for photomechanical processes and all graphic arts techniques;
- *papers* for document reproduction and for the ultra-rapid copy ('Gevacopy)';
- *films* for microcopying;
- *cine films* of all kinds and in all normal sizes (35, 32, 16 and double 8) for professional and amateur cinematography: negative, positive, reversal, duplicating and sound films, colour film 'Gevacolor' (negative, positive), 'Gevacolor Reversal' 16 and double 8 mm.;
- *X-ray films* for medical and industrial work;
- '*Scientia*'-*films and plates* for special scientific purposes: nuclear physics, autoradiography, photomicrography, quantitative and qualitative spectrography, Raman spectrography, electron micrography, oscillography, infrared photography, astronomy, etc.;
- *films and plates* for aerial photography;
- *papers* for professional and amateur use, and for scientific and technical purposes, bromide, chlorobromide and chloride papers in a great variety of types, contrast grades, surfaces and sizes. 'Gevacolor' paper;
- *photographic chemicals* for developing, fixing and toning of sensitive materials;
- a wide variety of filters for ordinary photography, for the graphic arts, for colour photography, for using in front of the lamps for colour grading in making colour prints, and for darkroom lamps;
- the Gevaert 2 × 8 Automatic and Zoomex *cine cameras* for the amateur (double 8);
- 'Gevasonor' *magnetic tape and film* for direct sound recording and reproduction;
- industrial *celluloid* for every purpose and *baryta paper*.



Photo : Sem Presser

PART ONE

PRINCIPLES OF PHOTOGRAPHY

Photographic Optics
The Sensitive Material
Processing

PHOTOGRAPHIC OPTICS

If a small hole is made in one side of a box and the side opposite the hole is replaced by a piece of ground glass we can see outlined on the glass an image of whatever is in front of the hole (fig. 1). This image, however, is far from clear, being both dim and blurred and consequently most imperfect, which is all that can be expected from such primitive apparatus. Nevertheless, the modern camera – even in its most highly developed form – is not essentially different from it.

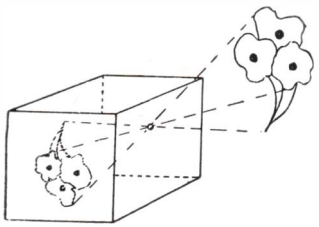


Fig. 1 An upside down and laterally reversed image appears on the ground glass since light travels in straight lines.

To secure a permanent record of the image produced on the side of the box opposite the hole, the ground glass must be replaced by a sensitive plate. The image produced on the plate after it has been developed is reversed in tone, dark parts of the object being clear in the image and vice-versa. This is called a *negative* and we shall see later that if this negative is printed by exposing it to light while in contact with a piece of sensitive paper, a second tone reversal takes place which restores the correct tone relationships of shadows and highlights. In this way a *positive* print is obtained. If a lens is placed over the hole made in the side of the box the image shown on the ground glass becomes much brighter, sharper and more distinct. It still has, however, some imperfections. By combining several glasses in a single lens the resulting image can be much improved and it is to this end that the *photographic lens* has been evolved.

In carrying out this experiment it will be found that in order to obtain a clear image of objects close to the lens, the lens has to be moved to a position further away from the sensitive plate, the separation increasing as the object is brought closer to the lens. It follows that some provision must be made for altering the distance from plate to lens according to the circumstances.* This is generally done by means of a bellows of cloth or leather, or sometimes, e.g. in miniature cameras, by using an adjustable lens or lens mount.

The plate must, of course, be exposed for a time long enough to allow the light to produce some usable effect on the sensitive surface, the duration of the

* In simple 'box' cameras and generally in all fixed focus cameras the lens is set to give sharp pictures from about 6 ft. to infinity. For closer distances some box cameras are provided with a supplementary lens called a 'portrait attachment'.

exposure, or *exposure time* naturally depends on how brightly the object is lit and on the sensitivity ('speed') of the film or plate, etc. The exposure time is controlled by a *shutter*.

A camera accordingly consists basically of two parallel, vertical plates joined by a bellows and capable of being moved closer together or further apart. The front plate holds the lens and the back one the ground glass screen, on which the image can be examined and focused. When a negative is to be made the ground glass is replaced by a sensitive plate. Cameras which use rolls of film or spools instead of plates are not provided with ground glass screens, in this case the image is lined up with the help of a *viewfinder* and focusing is accomplished by using a focusing scale previously calibrated. The 'directions for use' which accompany each camera give all the necessary instructions on these points.

Plate cameras are usually equipped with several *plateholders* (or darkslides), shallow metal boxes each holding a plate and fitted with a thin metal sliding cover which is removed when the holder is fitted to the camera and before the exposure is made (some cameras make use of double-sided wooden, metal or plastic darkslides and some of these are adapted to take cut sheet film instead of glass plates).

No darkslide is necessary for rollfilm which is wound on to a flanged metal spool at the factory and can be safely loaded into, and unloaded from, the camera in subdued daylight.



THE LENS

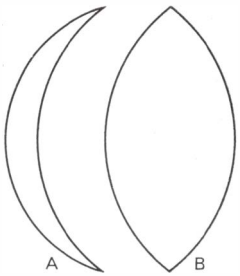


Fig. 2 (a) Meniscus lens. (b) Bi-convex lens. The edges of the lens are thinner than the centre. From this results spherical aberration, chromatic aberration and other optical defects.

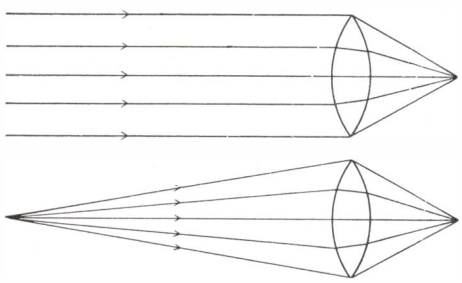


Fig. 3 In principle the convex lens causes all the light rays from a point in the object to converge towards a single image point.

Most box cameras are fitted with a simple lens, either a bi-convex or a meniscus (convexo-concave). This is nothing more or less than a good quality magnifying glass. The rays of light are so refracted or bent by this lens, which is always thicker in the centre than at the edges, that all the light rays which come from a single point and traverse the lens converge theoretically to a single point on the other side of the lens (figs. 2 and 3).

This is called the focus.* Later we shall see why we say 'theoretically'. At the moment, how do we interpret the term 'all the rays which come from a single point' and how do these rays form an image? Now each point of the object at which we are looking emits rays of light, either in fixed directions or in all directions. It does not matter at the moment whether these rays of light are given off directly by a *luminous source* of light or whether it is merely *reflected* light. It is sufficient, in order to understand the function of the lens, that each point of the subject being photographed gives off a bundle of light rays which are eventually brought together to a point on the sensitive surface (fig. 4).

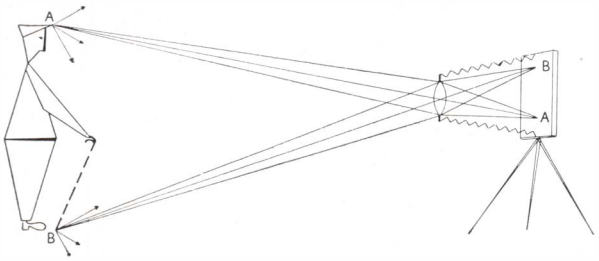


Fig. 4 Light rays come from each and every point in the subject just as they are shown coming from points A and B, and travel in all directions. All the rays arriving at the lens from one of these points are brought together in passing through the lens to a single point on the film or plate so that each object point gives rise to a corresponding image point.

* The focus of a lens is defined as the point at which rays converge from an infinitely distant point on the optical axis. The optical axis is the line joining the centre of each face of the lens.

← *Photo: Vittorio Pontiggia*

Limitations of the simple lens

The simple lens has many limitations and defects. These defects are due to the fact that the surfaces are curved instead of being flat. As a result the marginal or edge rays are not bent to converge at exactly the same point as the central rays (fig. 5). In addition, the tapered edges of the lens act as a prism and split up the light into the different colours of which it is made up. Refraction is greatest for the blue and violet rays and least for the red (fig. 6). The result is that with a lens such as this (large aperture) it is impossible to get a point image. If the central rays are focused then the clear parts are surrounded by diffused patches of light from the marginal rays and the combined results of all these patches is an unsharp or blurred image. An exactly similar result is produced by focusing the image produced by only the marginal rays (fig. 7).

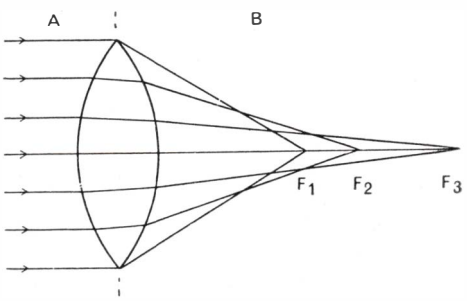


Fig. 5 Spherical aberration.
A. Rays coming from a single point at infinity, e.g. from a house 100 feet away.
B. Marginal rays bend more than central rays. Foci F_1 F_2 F_3 do not coincide.

It is easy to demonstrate this defect by trying to focus an image of the sun or a lamp on a sheet of paper. Try as one may, a sharp image is unobtainable.

The first defect is called *spherical aberration*, the second *chromatic aberration*.

How are these difficulties overcome? – by quite simple means – the marginal rays are intercepted so that the image is formed solely by the central rays. This is done by a *diaphragm* about which more will be said later on (see fig. 8). This is the method which is used in practice on box cameras.

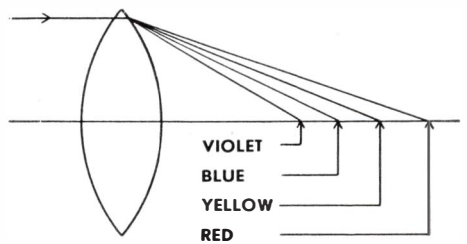


Fig. 6 Chromatic aberration or colour fringing.
As a result of the prismatic effect of the edges of the lens different colours are refracted different amounts and white light is split up. The difference in the focal length between the blue-violet light and the yellow is – for ordinary glass – about 1/50th of the focal length. This difference is called the dispersion.

This is not accomplished without disadvantages, since in cutting off the marginal rays a good deal of the light is discarded.

Consequently a method was sought and has been found for using the marginal rays and yet avoiding this disadvantage. It consists of using two lenses of different glasses in conjunction, one biconvex and the other biconcave, thus giving a lens of

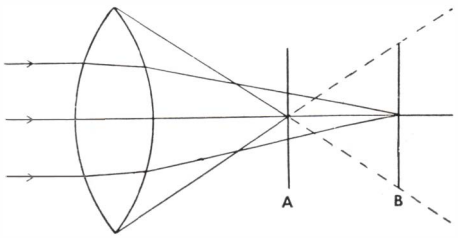


Fig. 7 A. Marginal rays focused: central rays form an out-of-focus spot.
B. Central rays focused: marginal rays form an out-of-focus patch.
In each case a point object is not reproduced as a point image.

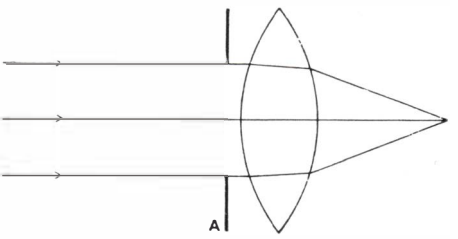


Fig. 8 Diaphragm (A) cutting off the marginal rays.

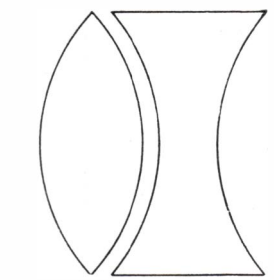


Fig. 9 'Aplanatic' lens of the same thickness throughout. The convex lens is of 'crown' glass, the concave of 'flint' glass.

practically the same thickness throughout (fig. 9).*

It follows, however, that this type of lens cannot concentrate or bend together the rays of light at all if the two lenses are made of the same glass, since the negative (biconcave) lens will re-disperse the rays that have been converged by the positive (biconvex) lens to an exactly corresponding degree. The concave lens is, therefore, made of a type of glass (flint) which disperses the rays less than the convex lens converges them (crown glass).

But is such an arrangement entirely aberration free? Unfortunately not. There still remain several others, in particular *astigmatism*, which results in a point object being imaged as a line or as a small cross; there is also *curvature of image field* (fig. 10), which has the effect of making the edges of the image less sharp than the centre (or vice-versa, the edges sharp and the centre blurred according to the focus setting selected).

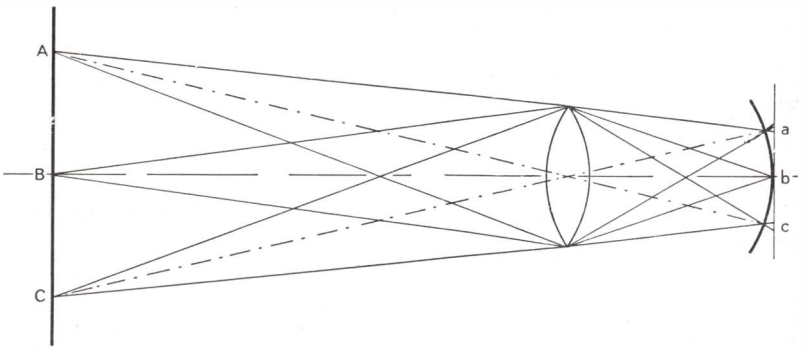
These defects, and some others in addition, are generally overcome in an *anastigmat* lens, i.e. a combination of at least three glasses, all of which are specially selected optical glasses. The successful elimination of aberrations requires that the curvatures of the surfaces and the separations of the individual glass elements shall be very precise.

* If red light plays an important part in image formation, as may happen in production of colours in the graphic arts, it is not sufficient to eliminate the difference in focus between the blue-violet and the yellow (achromatic lens). The focus for red light must also be made to coincide with that for the other colours (apochromatic lens).



Trafalgar Square – Photo: John Erith

Fig. 10 Curvature of field.
Rays from A, B and C in the object are not imaged on a plane by the lens. As a result, points A and C are seen on the negative as small circular patches (a and c). Only the best modern anastigmats give a really flat field.



The focal length

The focal length of a lens, when it is focused on infinity, is the distance between the ground glass and the rear nodal (principal) point of the lens. It would take too long to explain exactly what is meant by the 'rear nodal point' and 'front nodal point' of the lens. It is sufficient to state that they are normally fairly close to the diaphragm on the optical axis of the lens. (In the case of telephoto lenses however, the rear nodal point is some distance in front of the lens.)

Several different methods may be used to determine the approximate focal length without resorting to optical calculations. Here is one of the simplest:

Focus the lens on a distant point, say a house a hundred or more feet away. Measure the distance between a point A on the fixed body of the camera and a point B on the movable part of the camera, call this distance '*a*'. Now refocus the camera on a nearby object (e.g. at 3 ft.). Measure the distance between points A and B again and call this distance '*b*'. Finally measure the height of the ground glass image (=*h*). If the height of the object is H then the focal length is given by:

$$F = (b-a) \times \frac{H}{h}$$

Example: The distance between A and B is 4 in. for the infinity focus setting (a=4 in.) and 5 in. for the close-up setting (b=5 in.). The object height H is 12 in. and the image height '*h*' is 3 in. What is the focal length?

Answer: By substituting in the formula above the corresponding values we have:

$$F = (5-4) \times \frac{12}{2} = 6 \text{ in.}$$

The focal length is therefore 6 in.

The focal length of a lens is usually given in inches or in centimetres, but may also be expressed as it often is by opticians in *diopters*. What do we mean by a diopter? The refractive power of a lens having a focal length of 1 metre is equal to one diopter. A lens of focal length f metres has a power of $1/f$ diopters, the power in diopters is the reciprocal (or fraction) of the focal length (in metres). In other words, the power in diopters increases as the focal length is shortened. Opticians find diopters a useful measure since the power of two lenses used together is obtained by simply adding together their separate powers in diopters.

Example: The refractive power of a lens of 20 cm. focal length is $\frac{100}{20} = 5$ diopters. Conversely a lens of power 5 diopters has a focal length of 1/5th of 100 cm., i.e. 20 cm.

Positive lenses (which converge or concentrate light) are distinguished by a plus sign +, the lens in the example above has a power of +5D.

The power in diopters of a negative lens is equal (and opposite) to the power of a positive lens which exactly counteracts its dispersive power. Accordingly the negative power of the lens is shown by the minus sign – preceding the numerical value of the power. A negative lens which is exactly neutralized by a positive lens of power +3D therefore has a power of −3D.

Image size

The image size is directly proportional to the focal length. Fig. 11 shows how the image size is doubled if the focal length is doubled. As is clearly shown in the drawing the areas ABCD and EFGH are equal while EFGH is only one-quarter the area of A′B′C′D′, and consequently is illuminated to only one-quarter the brightness of ABCD. If follows that if the diameter of the aperture (diaphragm opening) is exactly the same in both cases (all other things being also equal) EFGH will need an exposure time four times as long. If the focal length is tripled the image area will be $3 \times 3 = 9$ times as great. *The area of the image is directly proportional to the square of the focal length.*

To make up for this reduction in brightness the lens has to be made to pass more light and if the focal length is increased n times then the *diameter* of the aperture (or stop) used must also be multiplied by n (so increasing the area of the glass that transmits light from the object by n^2).

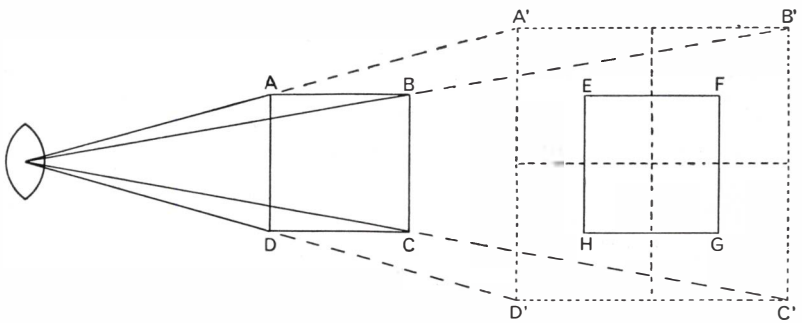


Fig. 11 The area of the image is directly proportional to the square of the focal length.

Another way of looking at this matter is as follows. We have seen that EFGH receives only a quarter of the intensity of light that ABCD does, and that in order to image the same amount of the object on the ground glass this has to be four times larger. In these conditions the total quantity of light falling on ABCD has to be spread over the area A′B′C′D′. Since A′B′C′D′ is four times the area of EFGH (itself equal to ABCD), we can easily see that for *equal*

aperture diameters (or absolute apertures) a lens of twice the focal length has *only one-quarter* the light passing power.

Similarly, we can say that a lens of three times the focal length passes $3 \times 3 = 9$ times less light, and one of four times the focal length passes $\frac{1}{4} \times \frac{1}{4} = 1/16$th of the light.

This is summed up in the following formula: the light collecting power ('speed') of a lens is inversely proportional to its focal length squared (for a fixed aperture size), and it is independent of focal length.

Object distance and focusing range

We have already seen that light rays arriving at the lens will only intersect at the focal plane if they come originally from an object at *infinity*. As the object to be photographed is brought closer to the lens the bellows or extension has to be increased in order to produce a sharp image since the image will then be focused at a point beyond the principal focus.

Fig. 12 shows how an image is formed. L represents a section through the lens, P the object, f the focal length, and B the image. The distance between the lens and the object is called the 'object distance' and that between the image and the lens the 'image distance'.

If the object distance is exactly twice the focal length the object is reproduced exactly life size. The distance, then, between the rear principal point (for practical purposes the centre of the lens) and the image is also $2f$.

In symmetrical two element lenses the two principal points coincide for all practical purposes with the centre of the iris diaphragm and above we have called this plane the section through the lens.

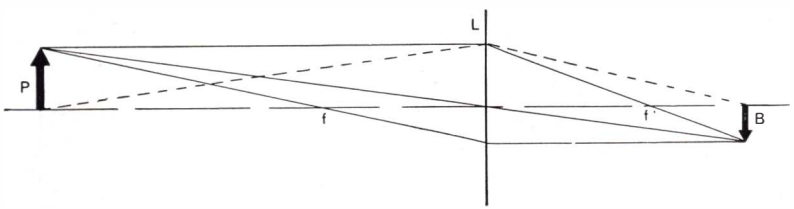


Fig. 12

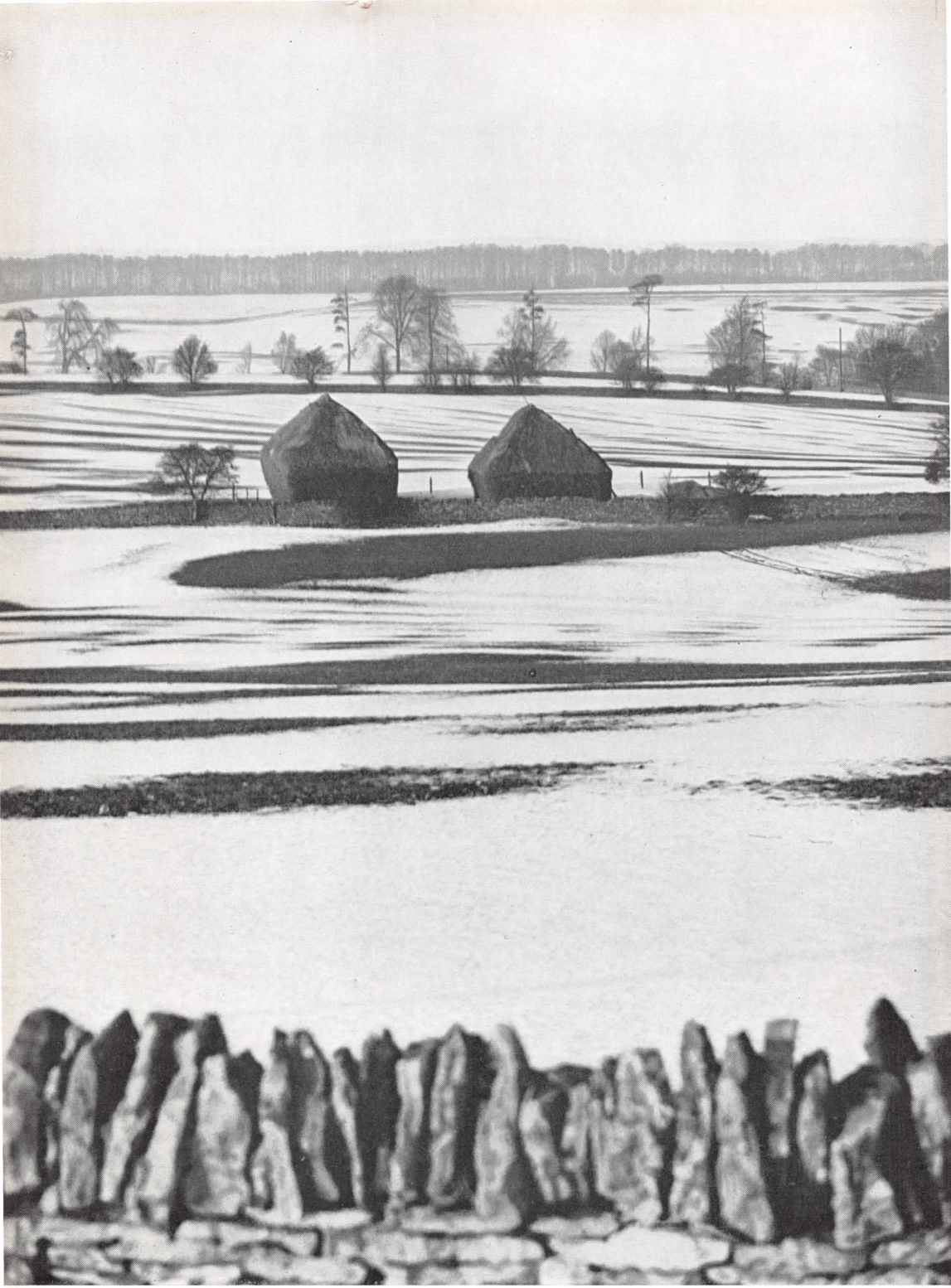
If it is desired, say, to obtain an image n times larger than the object, then the image distance will be $n+1$ times the focal length. The object distance will be the image distance divided by n or $\frac{n+1}{n}$ focal lengths.

Example: It is required to have an image $2\frac{1}{2}$ times larger than the object with a lens of focal length 4 in. In this case the image distance will be $(2\frac{1}{2}+1) \times 4 = 14$ in. and the object distance will be

$$\frac{(2 \cdot 5+1) \times 4}{2 \cdot 5} = \frac{14}{2 \cdot 5} = 5 \cdot 6 \text{ in.}$$

If, however, a reduced image is required n' times smaller than the object the object distance is now $n'+1$ times the focal length and the image distance is:

$$\frac{n'+1}{n'} \text{ focal lengths.}$$



Angle of view

When a lens is fitted to a large camera provided with a ground glass and the shutter is opened, a large illuminated circular area containing the image can be seen. This circular area is the field of view of the lens. If the lens is focused on infinity (e.g. on a church about a quarter of a mile away) and the ground glass image is examined carefully it will be observed first that the brightness of the image falls off progressively towards the edges of this circle and also that the definition (or sharpness) also decreases towards the periphery.

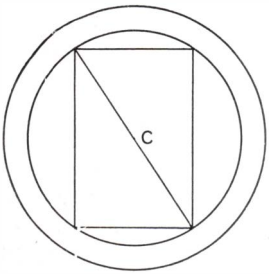


Fig. 13

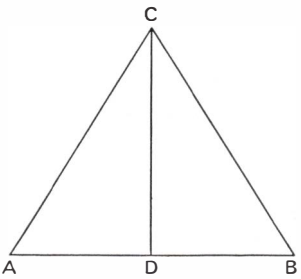


Fig. 14

It will readily be seen that the ideal would be to have an image which is sharply defined and evenly illuminated over *the whole area*. The circle – called the circle of good definition – which gives a reasonable approximation to this ideal is considerably smaller than that to be seen on the ground glass. It is the diameter of this circle which determines the length of the diagonal of the film or plate which can be usefully covered by the lens, that is the largest usable size (see fig. 13).

The size of the image and the focal length of the lens are the two factors which determine the *field of view* or the field angle for critical definition.

The angle of view is the angle formed by the extreme rays that pass through the optical centre of the lens to form the image.

This angle incidentally depends somewhat on the stop used. With a small stop the circle of good definition is extended. This explains why some professional lenses are specified as having two angles of view, one for full aperture and a larger one when stopped down to small apertures.

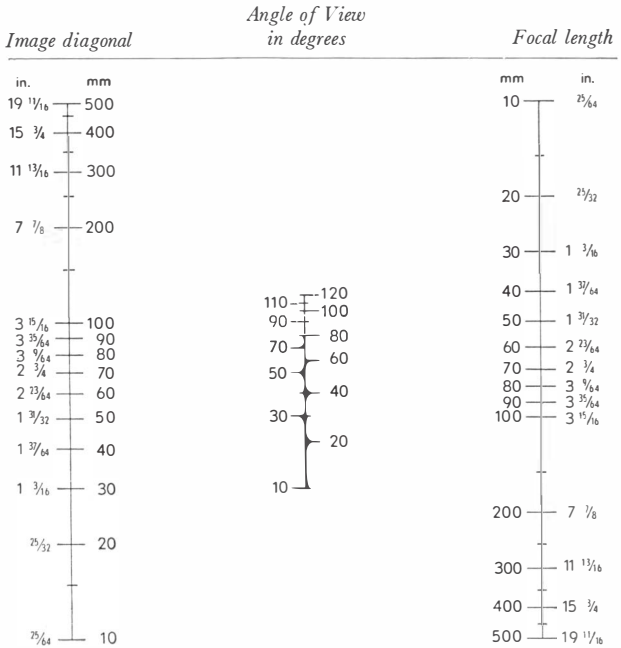
It is true to say in general that the better the lens is corrected for chromatic and spherical aberration, for astigmatism, curvature of field, etc., then the greater the angular field covered at critical definition. An anastigmat accordingly covers a larger field than an aplanat or doublet of equivalent focal length and aperture.

To determine the angle of view proceed as follows: Draw a line AB (see fig. 14) of length equal to the diagonal of the largest usable image and plate size. Construct a perpendicular DC from the middle point D of AB equal to the focal length of the lens. Join A and B to C. The angle ACB is the angle of view. This angle can be measured with a protractor.*

* We have considered here only the infinity setting. Since the image moves away from the principal focus for all closer objects the actual circle produced by this field angle increases in size and is *twice* as large when the image is life size. For this reason, copying lenses often have the plate sizes that are covered sharply listed according to the scale of the reproduction.

With ordinary general-purpose lenses the field angle is usually about 50°. In this case the diagonal of the negative is about equal to the focal length. Portrait lenses are normally narrower, angled – about 35° – to procure a better perspective. Conversely angles of 85°, 90°, or even 100° are used with wide-angle objectives.

There follows a chart (nomograph) which allows the easy determination of angles of view for the normal range of focal lengths and plate sizes.



Place a ruler to intersect the number in the left hand column, which corresponds to the diagonal of the image (or or the plate or film in use) and the number in the right hand column corresponding to the focal length of the lens. Read off the angle of view where the ruler crosses the centre scale.

Table A given in Part VI gives the most normal focal lengths between 3·5 and 80 cm. and the field angles corresponding to the common plate sizes between 2·4 × 3·6 cm. and 70 × 80 cm.

Relative aperture and image brightness

In the section on image size, page 10, we showed that the light gathering capacity of a lens depended on the focal length in the sense that – everything else being equal – the image brightness falls off progressively as the focal length increases. Close scrutiny of fig. 11 reveals that when the focal length is doubled *the same* quantity of light is spread over an area four times as great.

If the focal length is tripled this area becomes $3 \times 3 = 9$ times as great. The area of the image is, therefore, proportional to the square of the focal length. The image brightness is consequently *inversely* proportional to the square of the focal length. The image brightness does not, however, depend only upon the focal length, but also on the size of the diaphragm opening used. The larger

the stop diameter the brighter the image, a lens of large diameter, or large aperture, collects from each object point a larger bundle of light rays than that received by a smaller lens.

All the image points receive more light as the diaphragm is opened wider (see fig. 15). Two circular openings are shown there in section, their areas being proportional to the square of their diameters, and therefore we can say in principle that the image brightness and hence the light gathering power of a lens is directly proportional to the square of the maximum usable diameter of the diaphragm.

Combining all that has gone before we have the image brightness produced by a lens directly proportional to the square of the diameter of the diaphragm aperture (d) and inversely proportional to the square of the focal length (f). The image brightness can therefore be expressed as d^2/f^2. For a lens having a focal length of 5 in. and a stop diameter of 1 in. the image brightness is consequently proportional to $\frac{1}{5}\times\frac{1}{5}$ i.e. to $\frac{1}{25}$. It is generally, however, preferred to express the image brightness (and light gathering ability of the lens) by the fraction $\frac{d}{f}$. For the above example this ratio or 'f number' is $\frac{d}{f}=\frac{1}{5}$ and is generally written $f/5$ and frequently in the manner $f:5$.

It can easily be deduced from the foregoing that a very large lens is not necessarily one which gives a very bright image:

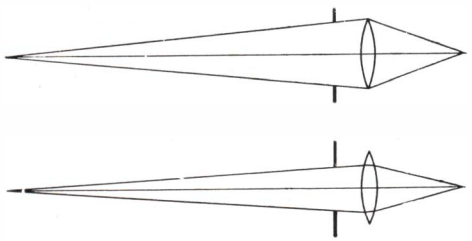


Fig. 15 Every part of the image becomes brighter as the diaphragm is opened.

Consider, for example, firstly a $3\frac{1}{4}$ in. $\times$ $2\frac{1}{4}$ in. camera with an $f/3\cdot5$ lens of 4 in. focal length, and secondly a $3\frac{1}{4}$ in. $\times$ $4\frac{1}{4}$ in. camera ($\frac{1}{4}$ plate) with a $5\frac{1}{2}$ in. focal length working at the same aperture. Both cameras have practically the same angular field. They give well defined images of identical extent, that is, if they are both set up side by side to photograph the same scene the $3\frac{1}{4}\times4\frac{1}{4}$ camera will show on the ground glass exactly the same picture as on the $3\frac{1}{4}\times2\frac{1}{4}$ only it will be larger.

We can see, as a consequence, that if, for the same object photographed from the same position, we choose two lenses having the same actual aperture diameter (say 1 in.) therefore collecting the same amount of light the $3\frac{1}{4}\times4\frac{1}{4}$ camera has to distribute this light over a larger area than the $2\frac{1}{4}\times3\frac{1}{4}$ camera. Under these conditions the image given by the $3\frac{1}{4}\times4\frac{1}{4}$ will be less bright than that given by the $2\frac{1}{4}\times3\frac{1}{4}$ camera. A longer exposure time will have to be given with the larger camera to give an equivalently exposed result.

To overcome this disadvantage, a larger sized stop diameter has therefore to be used corresponding to the increase in the focal length, so giving the same *relative aperture.*

Applying this to the example above we find that if the 1 in. diameter with the 4 in. lens in the $2\frac{1}{4}\times3\frac{1}{4}$ camera has a relative aperture of:

$$\frac{d}{f}=\tfrac{1}{4}=f/4$$

To give the same image brightness the $5\frac{1}{2}$ in. lens on the $3\frac{1}{4}\times4\frac{1}{4}$ camera would have to have a usable fully open diaphragm diameter of:

$$\frac{5\frac{1}{2}}{4}\text{ in.}=1\cdot375\text{ in. }(1\tfrac{3}{8}\text{ in.})$$

as compared with the 1 in. of the lens on the $2\frac{1}{4}\times3\frac{1}{4}$.

Loss of light in lenses

From what we have seen it would be reasonable to suppose that two lenses of the same relative aperture (e.g. $f/4 \cdot 5$) ought to give in practice images of equal brightnesses. This is, however, not always the case. It is necessary to take into account both the loss of light by absorption in the glass and more especially the light lost by reflection at the air-glass interfaces of the lens elements. While the loss by absorption is small, that lost by reflection is very considerable.

The following table, published by L. P. Clerc, shows:

1. Values of the lens transmission for different total glass thicknesses, i.e. the percentage of transmitted light after absorption.
2. Values of the lens transmission after reflection at the interfaces of the lens elements.

1. Thickness in cm.	1	2	3	4	5	6	
Transmission %	99·5	99	98·5	98	97·5	97	
2. No. of glass-air surfaces . .	2	4	6	8	10	12	
Transmission %	89·7	80·4	72·1	64·6	57·9	51·7	

These losses are for well polished lenses of clear glass. To arrive at the approximate total transmission of a lens the two appropriate transmissions must be multiplied together.

Example: A three-element air-spaced lens (triplet) of total glass thickness 2 cm. transmits $72 \cdot 1 \times 0 \cdot 99 = 71 \cdot 4\%$ of the light incident on it.

If two lenses of the same type are used under the same conditions (i.e. same relative aperture, same angular field) and differ only in their focal length then the one with the longer focal length will give the least bright image since it must be thicker than the other lens.

In the example above the total transmission for a thickness of 4 cm. is $72 \cdot 1 \times 0 \cdot 98 = 70 \cdot 7\%$ instead of $71 \cdot 4\%$, i.e. more light is lost.

In cemented lens the loss of light at the cemented interface is negligible.

The effect and avoidance of internal reflections

Loss of light is not the only or even the most serious consequence of the internal reflections which take place in large aperture objectives. Light rays which have no part in forming the image proper are thus admitted inside the camera and are most detrimental.

This light, which is called 'flare light', falls on to the sensitive surface and produces local or general fogging or secondary images. A small amount of general fogging or veiling usually gives a flatter, less brilliant image. Localized fogging or secondary images can make the negative unusable.

A well-known defect is the luminous halo or ring. Fig. 16a shows how it is produced. Rays of light from the object are bent by the lens, and if focused correctly, come to a focus in the image plane: at the same time, however, a small fraction of the light is scattered by the air-glass surfaces. In the figure is shown what happens at the two faces of one of the lens elements. The reflected rays come to a focus at F′. The flare patch shows up most clearly when the focus is close to the image plane. If F′ falls well clear of the image it does not produce a patch as such but the light rays give rise to more or less general fogging. Sometimes it forms a distorted image of the diaphragm opening.

This defect is much more likely to arise with certain lenses if a very bright source of light is photographed against a dark background. Fig. 16b shows this distinctly. The flare image of the diaphragm in the lower right hand corner is diametrically opposite the bright light source.

It is very easy to find out where in any lens these unwanted internal reflections arise. To do this set up the camera with open shutter focused on infinity and pointing at the sun. Then examine the ground glass image. If the camera is not fitted with a ground glass open the back and fit one temporarily for this test.

Street in San Francisco – Photo: Reinhart Wolf →


CLIFT
LITTLE PINE
PARKING
1 HOUR
7AM TO 6P.M.

The camera should be set up in such a way that the image of the sun falls away from the centre of the ground glass somewhat in the manner of the light source in fig. 16b. Stick over the image of the sun a small piece of black paper to shield the eyes from the glare. The unwanted flare patches will easily be detected on the ground glass if the camera is directed at a very bright source, a point source if possible, viewed against a dark background as in fig. 16b.

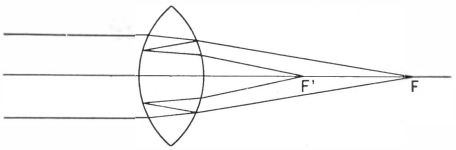


Fig. 16a A practical example of the luminous halo.

In order to reduce the deleterious effect of internal reflections the designers choose lens curvatures and separations such that the focus of the internal reflection falls well away from the focal plane. In this way they avoid, at least in current designs, secondary images, but the weak general fogging persists.

There has naturally been an intensive search for an effective method to eliminate internal reflections. Fluorite treating of the air-glass surfaces has yielded good results. This is a surface coating of the glass elements with a thin layer of fluorite, which can be applied to any lens and increases the effective transmission by amounts ranging from 20–40%, the depth of field being unaffected. In addition, most of the faults discussed above are either reduced or completely eliminated and the resulting images are noticeably more crisp and contrasty. Surface treatment of air-glass interfaces is now practically universal. The best optical authorities do not, however, generally advise the dismantling and treatment of old lenses.



Fig. 16b The luminous halo.

Lenshood

Simple as a lenshood may be it is of very great importance in photography. It is in effect only a small matt black tube pushed on the front ring of the lens mount to block off the direct rays from the sun and prevent them striking the front of the lens directly.

If you have no lenshood then the lens can be shaded from direct sunlight by the use of the hand or a hat. You run the risk of inadvertently obscuring part of the field of view and in addition rays reflected from a shining surface or from a water surface can enter the lens from below. The best lenshoods ('sunshades') are so designed that only the light actually coming from the subject can reach the lens. The lenshood should therefore be rectangular in shape at the front, or in the case of a $2\frac{1}{4}$ square format, square. A proper lenshood must always be accurately designed for the camera and the lens it is intended to be used on.

Always fix a lenshood to your lens for against the light shots. To be confident of complete safety one should in fact always be used especially for work in artificial light. A lenshood is particularly useful in rain not so much to cut off reflected sunlight from damp pavements and pools of water on the ground but to protect the lens from raindrops. It is also worth remembering that a lenshood can be used to hold a yellow filter or a supplementary lens.

It is important to fit the lenshood properly into position on the lens mount, or some of the image will probably be cut off. A rectangular lenshood must obviously be attached with the longer sides parallel to the longer sides of the film or plate.

★ A useful formula

Whatever shape of lenshood is to be used it must be designed so that all the image forming rays can reach the front lens surface.

If the front opening is rectangular its dimensions are given by the following formula:

$$l = d + \frac{L \times A}{F} \text{ and } h = d + \frac{H \times A}{F}$$

where l=longer side of hood h=shorter side of hood.

L=larger side of film (or plate) H=shorter side of film (or plate).

d=maximum diaphragm opening.

F=focal length of lens.

A=distance from front of lenshood to optical centre of lens.

All dimensions should obviously be in the same units, inches and fractions of any inch or centimetres and millimetres.

Example: What dimensions should l and h be for a $2\frac{1}{4} \times 3\frac{1}{4}$ camera with a 4 in. lens of aperture $f/4 \cdot 5$?

The maximum aperture of diaphragm $d = \frac{4 \cdot 5 \text{ in.}}{4 \text{ in.}} = 0 \cdot 9$ in.

The distance from the diaphragm to the front face of the lenshood is to be A=1·25 in.

Substituting these values in the formula above we have

$$l = 0 \cdot 9 \text{ in.} + \frac{3 \cdot 25 \text{ in.} \times 1 \cdot 25 \text{ in.}}{4} = 1 \cdot 9 \text{ in. (approximately).}$$

$$h = 0 \cdot 9 \text{ in.} + \frac{2 \cdot 25 \text{ in.} \times 1 \cdot 25 \text{ in.}}{4 \text{ in.}} = 1 \cdot 6 \text{ in. (approximately).}$$

If the hood is circular in section then the diameter (D) should be equal to

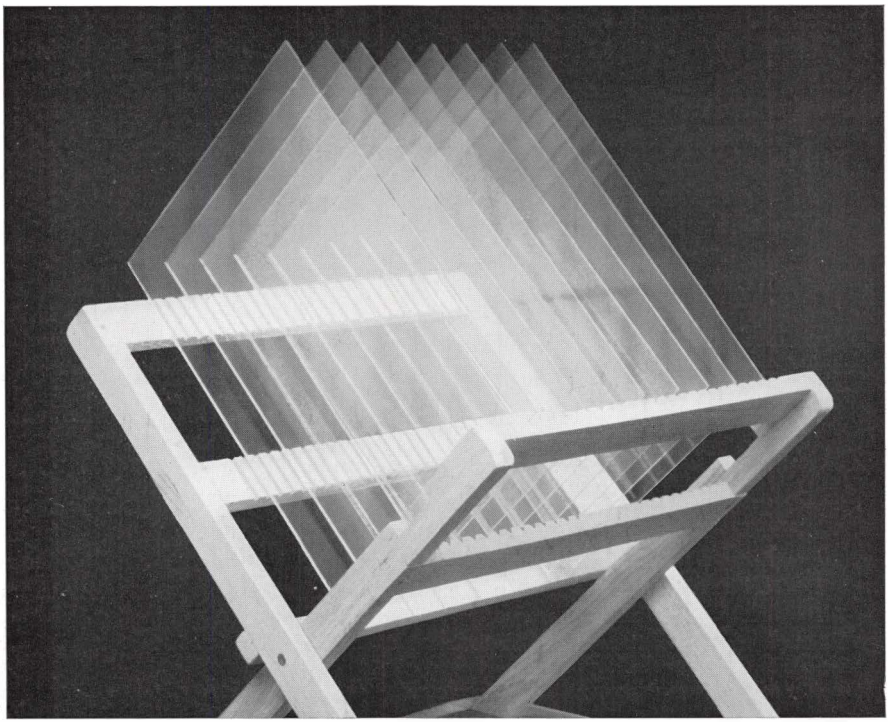
$$D = d + \frac{O \times A}{F}$$

where O=diagonal of film (or plate).

The results given by these formulae can only be approximate if the distance A is taken to be the distance between the diaphragm and the front of the lenshood.

A useful practical method is to construct the lenshood a little deeper, say $\frac{1}{4}$ in., than provided for in the calculations. Before it is finished, fit it correctly to the lens mount and examine the lens with one eye only and the stop wide open from each corner of the focal plane, opening the camera back to do so. A corner or portion of the hood will obtrude into the field of view. Mark this carefully with a pencil. Join all four marks and cut back the lenshood just inside the marks. Re-examine and check there is no interruption of image light. Then finish off. The very best hood is tailored to the lens and camera by this method.

Note: Some amateurs may think that because they possess a 'bloomed' or coated lens they can dispense with a lenshood. This is not so. A lenshood can be used to advantage with every lens.



Without polarizing filter

Polarizing filters

Photographing subjects with reflecting surfaces, such as display cabinets, polished marble, pottery, etc., is often difficult. The shining surfaces reflect some of the light and produce reflections of neighbouring objects. All this is recorded by the lens as a matter of course. Such effects are sometimes required but more often, especially in record photography, the operator tries to avoid reflections so that the object is recorded as faithfully as possible.

When he has to photograph say, a shop window or a framed picture, he must resort to any means to get rid of the reflections from the glass. A very satisfactory way of doing this is to use a *polarizing filter* or screen.

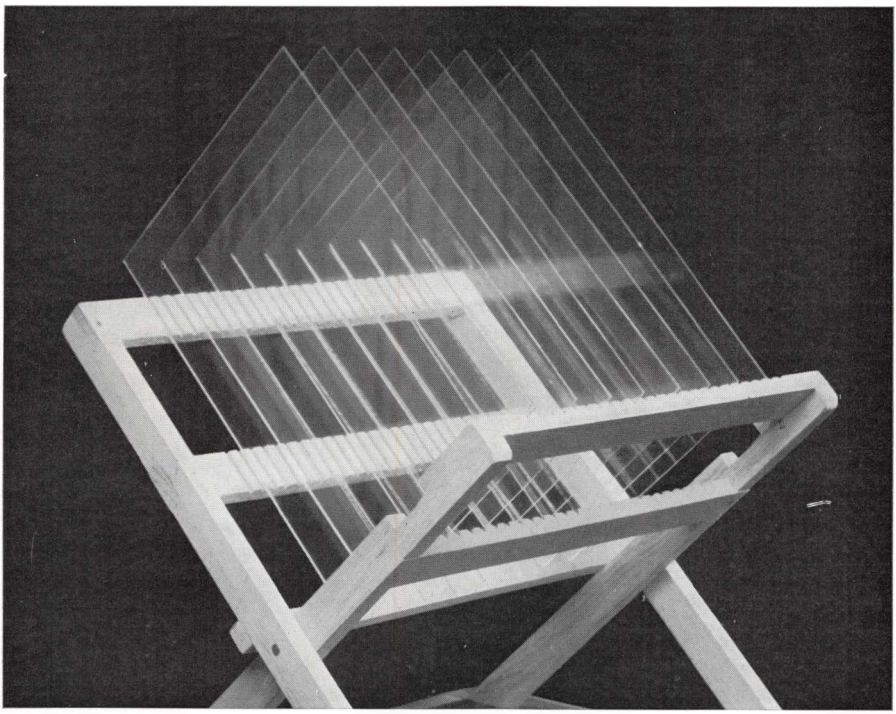
What is a polarizing filter?

Or to put it more clearly, what is polarization?

We know that light coming from a luminous source travels as waves, these vibrate and are not confined to one plane but oscillate randomly in all directions. This is so as long as the light does not encounter a mirror surface where it is reflected.

On examining reflected light we discover that the oscillations are no longer distributed over all possible directions but in one direction only, in a single plane (the plane parallel to the reflecting surface). The light is then called 'plane polarized' light and the operation producing this effect 'polarization'.

A polarizing filter is able to block totally or partially the passage of polarized light. The



With polarizing filter

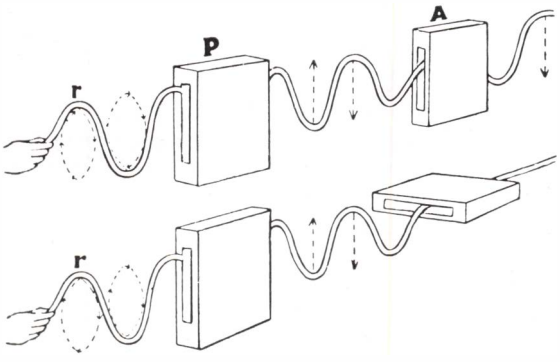


Fig. 17 Principle of polarization.

mechanical analogy shown in fig. 17 shows clearly how this occurs.

A rubber tube is made to oscillate erratically by turning and jerking up and down one end (*r*) by hand. Suppose the tube passes through a vertical slit P. What happens? The random oscillations are transformed in going through the slit into a simple up and down undulation. If the rubber tube now passes through a second vertical slit A, this movement is transmitted unchanged. If, however, the second slit is turned through a right-angle so that it is horizontal (lower part of the diagram) all the oscillation is removed in going through the second slit. If, however, the second slit is turned less than 90° the oscillation is reduced in proportion to the amount of rotation, i.e. is increased the further the slit A is from the 90° position.

Consider again the polarizing filter. 'P' (fig. 17) represents the cause (e.g. a glass) which polarizes the incident light in one direction. 'A' can be taken to represent the polarizing filter which, according to its position, will block completely or partially the polarized light.

A polarizing filter is a grid made up of microscopic crystals held between two optical glasses which is placed over the camera lens during the exposure. If the camera is provided with a ground glass viewing screen then the effect obtained can be readily observed.

Another method, suitable when there is no ground glass to examine, is to look at the subject through the polarizing filter from the camera position and to rotate it until the desired effect is produced. The filter is then placed on the camera lens in exactly the same orientation.

For glass, e.g. for windows and glassware, the light is polarized if it strikes the surface at an angle between 30° and 35°. To decide on the best place for the camera it is best to observe the subject through the polarizing filter and to keep moving about until the desired effect is achieved.

As well as the applications already dealt with there is another worth mentioning in passing.

Blue light from the sky is more or less polarized. With clear skies the polarization can be quite pronounced especially towards the north zenith. In landscape photography this effect can be put to good use by employing a polarizing filter to reduce the exposure of the sky without affecting the light on the foreground as would be the case if a yellow filter were used. It can be used with colour film to darken the sky.

By adding a red filter to a polarizing filter very interesting 'night effects' can be procured by this method in broad daylight.

Combinable (casket) lenses

Many lenses can be dismantled and their separate groups of elements used independently provided they are stopped down sufficiently. Symmetrical lenses made up of two identical components give two combinations, the complete lens, or one of the two halves used alone. With lenses which are asymmetrical or only semi-symmetrical, i.e. the two parts are not exactly similar, three focal lengths are possible, viz. the complete lens, the front component alone and the back component alone.

The number of combinations can be extended by using a 'casket' set of lenses, which consists of a lens body into which can be screwed a variety of components. It is possible with three such components to procure six individual focal lengths, with four components, ten focal lengths and fifteen focal lengths with five components.

Supplementary lenses

In place of these expensive collections of lenses amateurs use supplementary lenses which are placed in front of the normal camera lens. Two types are used, 'close-up lenses' (positive lenses) which shorten the focal length and distance lenses (negative elements) which increase the focal length.*

It is essential to centre these supplementary lenses precisely on the camera lens. Close-up lenses are generally sold in screw-on mounts or push-on mounts with friction-tight attachment. Good quality close-up lenses may also be attached by means of a properly designed and fitted hood (sunshade). Spectacle lenses of meniscus form are the best and should be fitted to the camera lens mount so that the convex face is towards the object.

A lens used with a supplementary is usually focused on infinity. To photograph an object at approximately 20 in. (0·5 metre) a supplementary lens of focal length 0·5 metre is required. i.e. a power of $1/0{\cdot}5=2$ diopters. The supplementary refracts rays coming from the object (which is at its principal focus) so that they are *parallel* when they fall on the camera lens and so appear to be coming from infinity.

* Positive lenses are thicker in the centre than at the periphery, negative lenses the opposite.

The image is therefore sharply focused in the focal plane of the camera. It follows that if used only in this way each separate distance requires a different supplementary lens.

It is, however, quite possible to use a *single supplementary for a number of different object distances.* The camera lens is not then set on infinity focus but on a distance T depending on the object distance.

To determine the setting T required for a given distance use the following formula:

$$T=U-S$$

where U=distance of the object from the lens (diaphragm) and S the power of the supplementary, *all the values being expressed in diopters* (see page 9).

Example: With a supplementary of 1·50 metres focal length (0·67D) it is desired to photograph an object at 1·20 metres (0·83D). What distance should the camera lens be set at?

Answer: $T = U-S = 0\cdot83-0\cdot67=0\cdot16D$

which is equivalent to $\frac{1}{0\cdot16}$ metre=6·25 metres. So the lens should be set at 6·25 metres or approximately 20 ft. For a spectacle lens of 0·5D (2 metres focal length) everything else unchanged, the correct lens setting would be:

$$T=0\cdot83-0\cdot5=0\cdot33D=3 \text{ metres.}$$

It is just as easy to determine at what distances objects will be sharply focused for a given setting of the camera focus. In this case the formula is rearranged into the form:

$$U=T+S$$

Example: For a close-up lens of 1·5 metres focal length (0·67D) and a camera lens scale setting of 5 metres (0·2D) the subject ought to be placed at $0\cdot67+0\cdot2 = 0\cdot87D$, i.e. $\frac{1}{0\cdot87}$ metres = 1·15 metres from the lens.

For all but the most careful calculations take 1 metre=40 in.

★ An alternative simplified formula

Example: The supplementary has a focal length of 1 metre (+1D) and a camera which can be focused as close as 1 metre. At what distance will the object be sharp if the camera lens is focused on 2·5 metres?

Answer: The distance (measured from the centre of the lens, or the diaphragm) at which objects will be sharp is found by multiplying the focal length of the supplementary (F) by the distance on which the camera lens is focused (d) and dividing the product by the sum of these two distances.

For the values given above we have:

Focal length of close-up lens: +7D=1 metre.

$$\text{Formula: } \frac{F\times d}{F+d} = \frac{1\times2\cdot5}{1+2\cdot5} = \frac{2\cdot5}{3\cdot5} = 0\cdot71 \text{ metres.}$$

i.e. 71 cm. approximately 28 in.

We have commenced above with a chosen supplementary lens and found out what we can do with it. Often the problem arises in the following form: what lens ought we to use to increase or reduce the focal length of our camera lens?

In this case the focal length of the lens should be multiplied by the focal length required and divided by the difference between them.

Example: We have a lens of 10·5 cm. focal length and want one of 8 cm. to give a wider angle. What supplementary is required?

Applying the formula we get:

$$\frac{8\cdot0\times10\cdot5}{10\cdot5-8\cdot0} = 33\cdot6 \text{ cm. = (approx.) 3D.}$$

Note: If the focal length were to have been increased we would have naturally required a negative lens (to reduce the power). The calculation would be the same but the sign would be changed.

Example: We have a lens of 10·5 cm. but in order to give a larger image of the object we want to increase the focal length to 12·5 cm. In applying the formula we have:

$$\frac{12\cdot5\times10\cdot5}{12\cdot5-10\cdot5} = 65\cdot5 \text{ cm. or} -\frac{1}{0\cdot655}\text{D.}$$

$= -1\cdot5$D (when the sign has been changed).

Close-up lenses (positive) reduce the focal length and so increase the aperture of a lens when set at any particular stop number.

If we consider a lens of 12·5 cm. focal length (i.e. $\frac{1}{0\cdot125} = 8$D) used with a supplementary of +2D the focal length of the combination reduces to:

$$\frac{1}{8+2} = \frac{1}{10} = 10 \text{ cm. (10D).}$$

The speed increases proportionally to the square of the relative aperture, i.e. inversely to the square of the focal length less the loss of light due to the additional absorption in the supplementary. In the example given the speed of the combination therefore increases to:

$$\frac{(12\cdot5)^2}{10^2} - 10\% = 141\%$$

of the original lens, i.e. a gain of 41%.

This gain in lens speed is, however, nullified if the diaphragm has to be closed down because the addition of the supplementary reduces the image definition. Distance lenses (negative elements) do not produce this defect except to a minor degree, but unfortunately since they increase the focal length the relative aperture of the combination is reduced, not increased.

★ Table for close-up lenses of +1 Diopters, +2 Diopters and +3 Diopters

Camera lens set on	+1D	+2D	+3D
	Lens (diaphragm) – object distance for above		
(ft.)	(in.)	(in.)	(in.)
∞	39	19½	13
100	39	19½	13
50	37	19	13
20	34	18¼	12½
15	32	18	12
12	31	17¼	12
10	30	17	11½
7	27¾	16	11
6	25½	15½	11
5	23¾	14¾	10½
4	21¾	14	10
3	18½	12¾	10

N.B. A lens of focal length 39 in. (100 cm.) = +1D
19½ in. (50 cm.) = +2D
13 in. (33 cm.) = +3D

To determine the focal length for a combination using a negative supplementary the same procedure is used as for a positive supplementary. The formula is identical but the number of diopters of the negative supplementary have to be deducted in this case and not added.

Close up lenses (positive supplementaries) are not to be recommended for portraiture. If, for instance, it is desired to produce a large portrait head a negative supplementary should be used. or if this is not practicable (because the camera has insufficient extension) the head should be photographed from at least 6 ft. away and the head *enlarged* afterwards at the printing stage. Only very small or very flat objects should be photographed from very close distances.



Photo : Joyce Rainboldt

Negative attachments are principally used for photographing distant scenes. With an ordinary lens they can also be of use in portraiture, since they increase the focal length and the picture can therefore be taken from a greater distance which helps to give an improved perspective.

Negative supplementaries can only be used with bellows cameras; this is a consequence of the increased extension required. As a general rule, a camera with double or triple bellows extension is required. Modern cameras with rigid metal focusing mounts are frequently provided with a graded set of extension tubes which allow the amateur user to employ negative supplementaries to advantage.

Telephoto lenses

For photography of distant objects it is best to use a telephoto lens. This type of lens is provided with a divergent (negative) element which is so placed that the bundles of rays from the front (positive) component pass through it and produce an enlarged image.

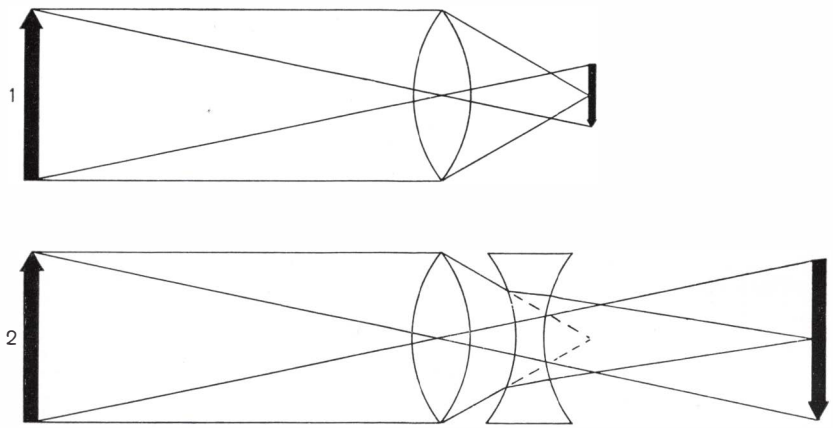


Fig. 18 Image formation with an ordinary lens (1) and with a telephoto lens (2).

Fig. 18 shows the image formation with a single positive lens. The parallel rays forming the arrow converge on the focus while the lenses passing through the optical centre show the size of the image. This is purely a schematic representation intended to show the optical proportions only. In fact the image is formed in the manner shown in figs. 4 and 12.

Fig. 18 (2) demonstrates how the addition of the negative element displaces the focus away from the lens at the same time giving an enlarged image of the arrow.

The enlargement of the image is very dependent on the separation of the positive and negative components, the increase in size being greater as the separation is reduced. There are telephotos in which this separation is fixed (telephoto lenses of fixed focal length) and other types in which it is adjustable.

Photo: Joyce Rainboldt →

As we have explained previously the focal length, etc., of a lens is generally measured from the plane of the diaphragm since, as a rule, it is good enough to take the principal point or 'rear nodal point' as being in that plane. In the case of a telephoto, however, this is not so, the principal point being well in front of the lens. As a result the camera extension required is a good deal less with a telephoto lens than that required with an ordinary lens which would give an equivalent image size. This allows the construction of a lighter more compact camera.

To find the focal length of a telephoto lens the focal length of the positive component is multiplied by the magnification ratio resulting from the addition of the negative element. If, for example, the positive component alone has a focal length of 4 in. and the image magnification produced by the addition of the negative element is 3x then the focal length of the complete combination is 4 in. $\times 3 = 12$ in.

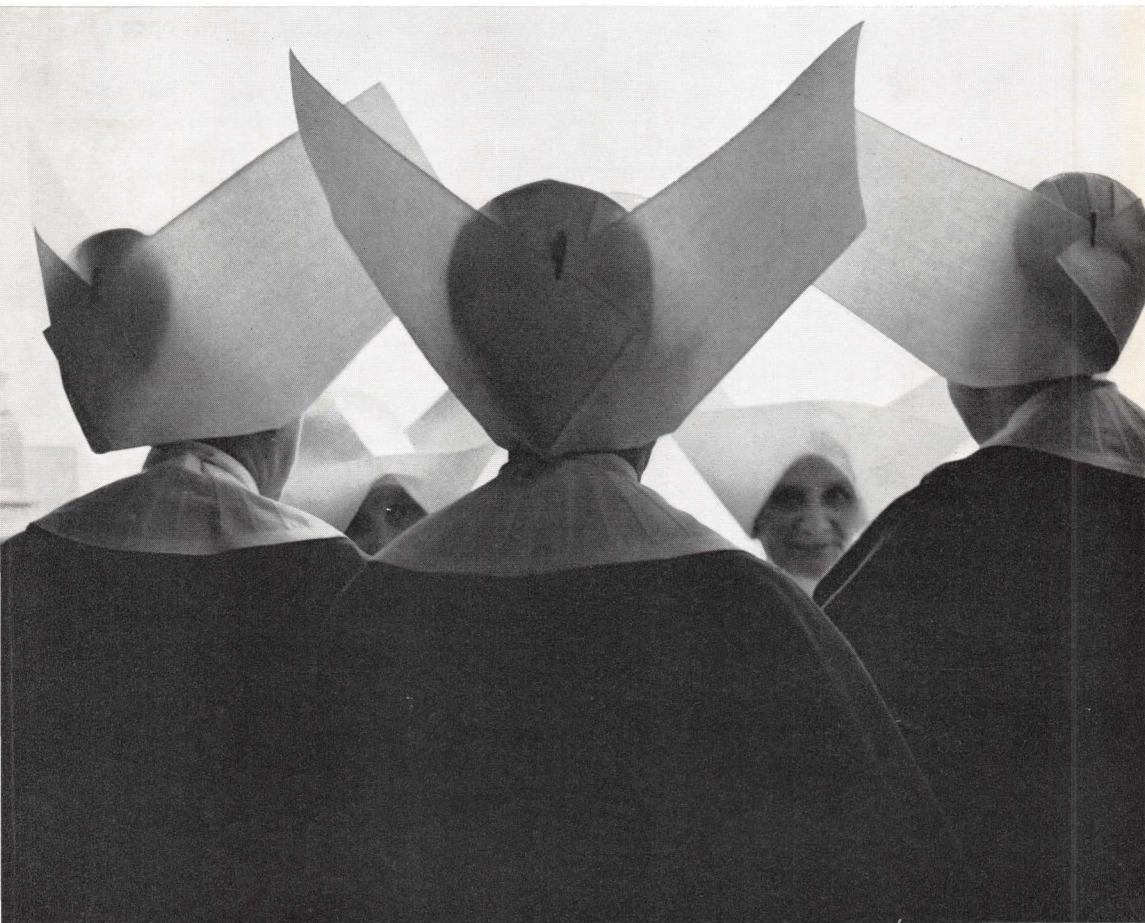
Variable telephotos with the distance between the positive and negative components adjustable give greater image magnification (power) as the negative component is brought closer to the positive. The focal length changes therefore with the position of the negative component.

It should be stated that in practice excessive reduction of the separation of the two elements causes a reduction of image definition.

Compared to normal lenses of the same focal length a telephoto lens requires far less camera extension to give the same image size. The lens system is designed so that the rear nodal point is not even near let alone in the lens itself, but well in front. As a result the construction is relatively light. It should be remembered that the image brightness decreases as the image magnification increases.

Telephoto lenses can be of considerable use not only for photographing distant objects but also to photograph very small objects (photomacrography).

The apparatus should be held on a very firm support since it will be readily appreciated that



the image brightness, especially for considerable magnifications, will be so weak that prolonged exposure times will be required. Any vibration will so reduce the definition that the advantage gained by the use of the longer focal length will be lost.

Care of lenses

Protect your lens with a 'lens cap'. Interchangeable lenses, supplementary lenses and the like should be kept in safety in the camera case or gadget bag in closed boxes. A lens can be cleaned but only when absolutely necessary. In doing so, adhere to the following routine: Make a small mark on the body so that the lens can be screwed back into exactly the same position. Screw back the front element into place before removing the back element. To remove dust and dirt use a soft sable brush or specially prepared 'lens tissue' and do not do anything else to the lens, especially 'coated' or 'treated' lenses.

A lens ought always to be held by its edges only. An obstinate screw thread can be eased by allowing a drop of benzine to run into it. Deep scratches or indentations in lens surfaces should be filled in carefully with adherent optical black varnish.

Keep both cameras and lenses in a dry place and do not expose them to the action of chemicals.

THE DIAPHRAGM

In good quality lenses the amount of light passed while the shutter is open can be regulated more or less precisely. This is done by the diaphragm.

The diaphragm is usually made of blades (fig. 19) which by sliding over each other can be made to close down from the fully open position (full aperture) as required. In this way the bundle of rays allowed through the lens can be restricted. The reduction in aperture can be indicated by the movement of a pointer along a graduated scale fixed to the diaphragm housing.

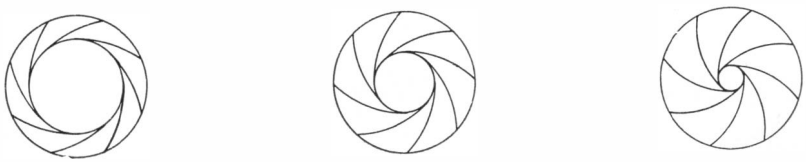


Fig. 19 The diaphragm is usually made of blades which slide over each other. This type is called an iris diaphragm.

There are other types of diaphragm such as the rotating diaphragm and the sliding (Waterhouse) stop. The Waterhouse stop consists of thin plates of brass, one carrying each desired aperture. Before exposure one of these is slipped into a slot in the lens body (fig. 20a).

The revolving diaphragm consists of a metal disc perforated near the edges with a series of holes of increasing diameter. This disc is eccentrically mounted in the lens so that the selected aperture can be turned as required on to the optical axis of the lens (fig. 20b).

Both these types of stop adjustments suffer from the disadvantage that the lens mount cannot be completely sealed off, both light and dust being able to get into the interior. Waterhouse stops are now only to be found in large lenses

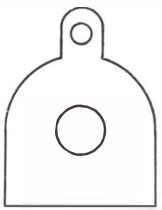


Fig. 20a The Waterhouse stop.



Fig. 20b Revolving aperture plate.

usually for process work, and rotating or sliding stop plates only in cheaper types of camera and sometimes also in wide-angle lenses.

The diaphragm performs three main functions:

1. In combination with the shutter it controls the amount of light entering the camera through the lens.
2. It cuts off the marginal rays, more especially with poorly corrected objectives.
3. It determines the depth of field (see below).

As well as the system of numbering the aperture that is described on page 15, there is another system (Universal) which is only found on much older apparatus. Table C, Part VI, gives particulars which will enable the owner of a camera so calibrated to convert the numbers given on the diaphragm so that it can be used according to the modern system described here.

To simplify photographic work, camera manufacturers have standardized the aperture numbers used so that the exposure is doubled (or halved) when the diaphragm is moved from one figure to the next. If at an aperture of $f/5 \cdot 6$ one second's exposure time is required to give a correctly exposed negative, two seconds' exposure time will be needed at the next smaller stop ($f/8$) and four seconds for the next ($f/11$).

Depth of field

As has been stated, the principal focus of a lens is the point where parallel rays from an object at infinity (or at a great distance) are converged by the lens. Rays coming from closer objects have another focus which is further away from the lens than the principal focus. Such is the case for all distances, the closer the object approaches the lens the further the focus moves away from it (see fig. 21). This is why the camera must be extended more and more as nearer and nearer objects are brought into focus. If the camera is focused at full aperture at a set distance, e.g. 30 ft., on examination of the ground glass image we can see that objects at 30 ft. are sharp, but objects in front of or behind this plane of sharp focus get progressively less and less sharp. There is, however, a certain range of object distances (e.g. from 24–40 ft. for a $3\frac{1}{4} \times 4\frac{1}{4}$ camera with a normal $f/4 \cdot 5$

lens) for which it can be agreed the images on the whole are acceptably sharp. This range of distances is called the *depth of field.*

It should not be thought that a *sudden* loss of image sharpness will be observed on the ground glass as a certain point is reached. As has already been said, there is a *gradual* and *progressive* loss of definition. There are no definite describable limits. All that can be seen with the naked eye is that some objects in front of and behind the distance focused on appear unsharp. It can also be seen that this lack of sharpness decreases as the diaphragm is closed down, but we will return to this later.

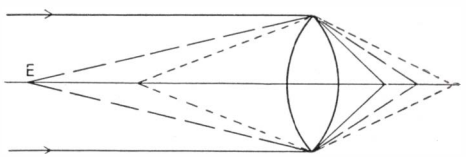


Fig. 21

It should never be lost sight of the fact that the only things that are really sharp are those at that distance on which the lens was initially focused; in other words, only the points on this plane and those alone are sharply reproduced in the image. Within the limits of the depth of field all the other image points are

Depth of field for 2 in. lenses
(Circle of confusion 1/500 in.)

Focused distance (feet)	Apertures													
	f/2.8		f/3.5		f/4		f/5.6		f/8		f/11		f/16	
	from	to	from	to	from	to	from	to	from	to	from	to	from	to
∞	50	∞	40	∞	35	∞	25	∞	17.6	∞	12.6	∞	8.9	∞
60	27.3	∞	24	∞	22.3	∞	18.3	∞	17	∞	11	∞	7.8	∞
30	18.7	75	17.6	120	16.6	210	14	∞	11.5	∞	9.3	∞	7	∞
20	14.3	33	13.3	40	12.9	46.6	11	110	9.6	∞	7.8	∞	5.10	∞
15	11.6	21.6	11.3	23.4	10.8	25.4	9.7	35.1	8.3	83	7.1	∞	5.9	∞
12	9.9	15.9	9.3	17.3	8.11	18.3	8.1	23	17.3	35	6.1	∞	5.5	∞
10	8.3	12.6	8.1	13.1	7.10	13.8	7.3	16	6.6	21.8	5.9	38.10	4.10	∞
9	7.6	11	7.3	11.6	7.1	12.3	6.8	14.6	6	20.1	5.4	33	4.5	∞
8	7	9.6	6.9	9.10	6.7	10.2	6.2	11.4	5.7	13.11	5.1	25.4	4.4	56
6	5.5	6.9	5.3	6.11	5.2	7.1	4.11	7.8	4.7	8.8	4.2	10.6	3.8	16.3
5	4.7	5.6	4.6	5.7	4.5	5.8	4.3	6.1	4	6.8	3.8	7.8	3.4	10.4
4	3.8	5.6	3.8	4.4	3.7	4.5	3.6	4.8	3.4	5	3.1	5.6	2.10	6.8
3½	3.4	3.8	3.3	3.9	3.2	3.10	3.1	3.11	3	4.2	2.10	4.7	2.7	5.4
3	2.10	3.2	2.10	3.2	2.9	3.2	2.8	3.4	2.7	3.6	2.6	3.9	2.4	4.2

really made up of small circular patches of light (circles of confusion) which are perceived however by the eye as true points. We shall see later that in fact the conception of depth of field is purely relative and depends on the criterion of sharpness considered necessary for any particular application.

The depth of field is greater behind the object plane of sharp focus than in front and this difference increases as the distance focused on increases and as the aperture decreases.

Depth of field for 3 in. lenses
(Circle of confusion 1/250 in.)

Focused distance (feet)	Apertures											
	f/3.5		f/5.6		f/8		f/11		f/16		f/22	
	from	to	from	to	from	to	from	to	from	to	from	to
∞	141	∞	86.1	∞	58.6	∞	43	∞	31.4	∞	21.5	∞
60	42.0	100.6	35.5	198.2	29.6	∞	24.11	∞	20.8	∞	15.9	∞
30	24.8	38.1	22.3	45.11	19.8	60.4	17.8	99.4	15.5	∞	12.5	∞
20	17.6	23.4	16	25.11	14.9	30.10	13.9	37.4	12.1	55.5	10.6	28.7
15	13.7	16.10	12.9	18.0	11.9	20	11.1	22.11	10.2	28.10	8.10	46.6
12	11.0	13.1	10.6	14.1	9.10	15.1	9.6	16.8	8.6	18.8	7.6	27.2
10	9.4	10.9	8.10	11.5	8.6	12.1	8.2	13.1	7.6	14.9	6.10	18.8
8	7.7	8.6	7.2	8.10	7	9.2	6.9	9.10	6.4	10.9	5.10	12.9
7	6.8	7.4	6.6	7.6	6.3	7.10	6	8.2	5.8	8.10	5.3	10.6
6	5.8	6.3	5.7	6.5	5.5	6.8	5.3	6.11	5	7.5	4.8	8.4
5	4.9	5.2	4.8	5.3	4.7	5.5	4.6	5.7	4.3	5.11	4	6.6
4	3.10	4.1	3.9	4.2	3.8	4.3	3.7	4.4	3.6	4.7	3.4	4.11
3 1/2	3.5	3.7	3.4	3.7	3.3	3.8	3.3	3.9	3.1	3.11	3	4.2
3	2.11	3	2.10	3.1	2.10	3.2	2.9	3.2	2.8	3.3	2.7	3.5
2 2/3	2.7	2.8	2.7	2.9	2.6	2.9	2.6	2.9	2.5	2.11	2.4	3

Example: With the lens of focal length 3 in. set for an object distance of 10 ft. with a stop of *f*/8 the depth of field extends from 8·6 ft. to 12·1 ft. There is, therefore, greater depth behind the distance focused on than in front. If the stop is closed to *f*/22 the depth of field stretches from 6·10 to 18·8 and is more than two times greater behind the object than in front of it. If the lens is focused on 15 ft. at *f*/22 the field will be 18 times as great behind than it is in front. A practical conclusion which follows from the above is that in general it is better to focus on a distance somewhat shorter than that required than one slightly greater. As a matter of fact the depth of field being greater behind than in front of the plane of sharp focus a slightly closer focus is easily accommodated.

Example: Suppose that for *f*/8 and F=3 in. we focus on 12 ft. instead of 15 ft.
The depth of field works out like this:
For focus set on 12 ft. it is from 9·10 ft. to 15·1 ft.;
For focus set on 15 ft. it is from 11·9 ft. to 20 ft.



Bolshoi Corps de Ballet in 'Giselle' – Photo: Houston Rogers

It can be seen from these figures that when the lens is focused on 12 ft. the distance on which the lens ought to have been focused, i.e. 15 ft., is well within the limits of the depth of field.

It is true that very often focusing on a setting somewhat greater will give as good a result, since the total depth of focus is then greater and provided the required distance is within the range, a greater total depth will result.

Here are the figures to illustrate this point:

For a focus on 15 ft. = 11·9 ft. to 20 ft. For a focus on 20 ft. = 14·9 ft. to 30·10 ft.

The correct focus still falls well within the depth of field, which is considerably greater behind than it is for the lens focus set on 12 ft.

However, it is frequently better to aim, on the whole, to set the focus to a somewhat closer point, in order to avoid too sharp a rendition of the background, which has the effect of making the subject stand out from the background giving pictures lacking in relief and naturalness.

Skilful use of the stop also allows the photographer to pick out his subject from its surroundings. If, for example, a child is photographed in a garden so that the flowers, foliage, trees, in fact all the surroundings are shown with the same degree of clarity as the subject itself, we are justified in asking what it was the photographer wished to photograph, the child or the garden. If, on the contrary, the focus is chosen so that the background is slightly unsharp, the emphasis falls naturally and clearly on the child. This method combined with skilfully chosen lighting can give results of striking naturalness or relief.

This manipulation of the diaphragm (stop) is an art which can only be acquired by practice and experience.

The extent of the depth of field depends on the following factors:
1. The distance on which the lens is focused.
2. The focal length, the depth is *reduced* as the focal length is increased.
3. The aperture. The depth of field is *reduced* as the aperture is increased (see fig. 22).
4. The criterion of the degree of sharpness required.

A few words are necessary about point 4. It is usually agreed that an image is sufficiently sharp if a point in the object is reproduced by a circle of about 1/250th of an inch. Inspected from the normal viewing distance of 10 in. this small circle actually appears to be a point. The diameter of the circle of confusion (or the amount of tolerable unsharpness) is then said to be equal to 1/250th of an inch. The use of miniature cameras imposes much stricter standards on the grounds that the negatives are to be considerably enlarged. Accordingly the circle of confusion is often chosen as 1/500th or 1/1000th of an inch.*

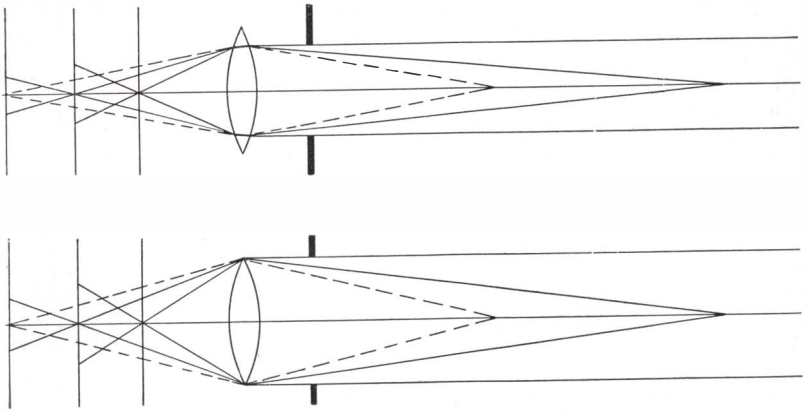


Fig. 22 The circle of confusion formed on the focal plane by points which come to a focus away from it is larger as the aperture is enlarged. The depth of field is accordingly reduced.

In sub-standard cinematography the tolerance used varies from 1/1000th to 1/2000th of an inch, this latter figure being applicable to 8 mm. film. The depth of field naturally is much reduced but the reduction is in turn largely offset by the increase in depth resulting from the fact that the focal lengths used in such cameras is much shorter than that of the lenses used in other cameras.

★ Formulae for depth of field

In order to be able to focus so that all objects between two selected distances from the lens are sharply defined, we must know:
1. What intermediate distance to focus on.
2. What aperture setting to use.

The intermediate distance to focus on can be determined from the following equation. T*m* represents the distance to which the focus is to be set, T*v* the near point and T*a* the furthest point:

$$Tm = 2 \times \frac{Tv \times Ta}{Tv + Ta}$$

Example: It is desired to photograph an avenue of trees, the nearest trees being 20 ft. away, the furthest 180 ft. What distance should the lens be focused on?

Answer: $Tm = 2 \times \frac{20 \times 180}{20 + 180} = \frac{20 \times 180}{100} = 36$ ft.

* A more general expression is to take the diameter of the circle of confusion as equal to 1/1000th of the focal length or, better still, for work such as critical cinematography F/1500.

In Table B, Part VI, will be found values of T*m* for various values of T*v* and T*a* up to 100 ft. and 20 m.

To find the aperture to be used the following expression should be used:

$$\text{Aperture} = 10 \times F \times F \times \frac{Ta - Tv}{Ta \times Tv}$$

In this formula F represents the focal length in inches. This expression is only valid for a circle of confusion of 1/250th in. Under paragraphs headed 'Hyperfocal distance' and 'Rapid calculations of depth' will be found other formulae from which the required settings can be calculated whatever circle of confusion is chosen.

Example: Using the values in the previous example. The camera used is a $3\frac{1}{4} \times 4\frac{1}{4}$ with a lens of a focal length of 4 in.

Answer: Stop No. $= 10 \times 4 \times 4 \times \frac{180 - 20}{180 \times 20} = \frac{160 \times 160}{3600} = f/7$ (approx.)

The diaphragm must then be set at *f*/7, in practice at *f*/6·3 or better *f*/8.

Note: It can be readily appreciated that it would be impossibly tedious to carry out these calculations on every occasion when a negative is to be made. They are to be found usually in a table of depth of field supplied with the camera. On many modern cameras such a table is fastened in a convenient place on the camera itself. Miniature cameras such as the Contax, Leica, etc., are provided with a set of depth of field indices engraved on the actual focusing ring of the lens mount.

★ The hyperfocal distance

When set at infinity the depth of field extends from a point in front of the lens to infinity. The distance from the lens to this *forward limit* of sharpness is called the hyperfocal distance. If the lens is now focused on this hyperfocal distance then everything between *half* this distance and infinity will be sharp.

The hyperfocal distance can be calculated from the following formula in which F is focal length in inches, *n* the stop (aperture) number and *e* the diameter of the circle of confusion selected:

$$H = \text{Hyperfocal distance in feet} = \frac{F \times F}{12n} \times \frac{1}{e}$$

Example: What is the hyperfocal distance for a lens of 2 in. (miniature) *f*/2? The circle of confusion is 1/750th of an inch.

Answer: $H = \frac{2 \times 2}{12 \times 2} \times 750 = 125$ ft.

(for $e = 1/1000$th in. H = 167 ft.)

The hyperfocal distance is 125 ft. When focused on this distance objects from $\frac{125}{2}$ ft. = 62 ft. 6 in. to infinity are sharp.

If the stop is closed down to *f*/8 the hyperfocal distance will be about 30 ft. and at a stop of *f*/16 15 ft.

Note: The formula for the hyperfocal distance is much simplified if a fraction of the focal length is taken as the diameter of the circle of confusion, e.g. 1/1500th $\left(e = \frac{F}{1500}\right)$.

The formula then reduces to:

$$H = \frac{F \times F}{12n} \times \frac{1}{F/1500} = \frac{F}{12n} \times 7500 = \frac{F}{n}.125$$

its simplest form.

This expression can be regarded as valid for all lenses of focal length up to 6 in., provided the focal length is more or less equal to the diagonal of the film or plate but not if a telephoto or wide angle were to be used.

Substituting on this formula the values used above we have:

$$H = \frac{2}{2} \times 125 = 125 \text{ ft. since } \left(\frac{2}{1500} \text{ in.} = \frac{1}{750} \text{ in.}\right).$$

★ The depth of field and hyperfocal distance

Calculation of the hyperfocal distance makes it easy to calculate the depth of field easily for each distance with sufficient accuracy.

For this purpose the expression used is:

$$\text{Depth of field} = \frac{H \times T}{H \pm T} \text{ i.e.} \begin{cases} \text{from } \dfrac{H \times T}{H+T} \\ \text{to } \dfrac{H \times T}{H-T} \end{cases}$$

Where H is the hyperfocal distance and T is the distance on which the lens is focused.

Example: Focus on 20 ft. with the camera used in the previous example, aperture *f*/8, the circle of confusion being 1/750th in. What is the depth of field? H at *f*/8=30 ft.

$$\text{Depth of field} \begin{cases} \text{from } \dfrac{H \times T}{H+T} = \dfrac{30 \times 20}{50} = 12 \text{ ft.} \\ \text{to } \dfrac{H \times T}{H-T} = \dfrac{30 \times 20}{10} = 60 \text{ ft.} \end{cases}$$

★ Direct calculation of depth of field

In the preceding paragraph we have worked out the depth of field by a roundabout way using the hyperfocal distance. This is the simplest method. There is, however, a standard formula from which the depth of field can be obtained whatever distance T the lens is focused on.

Here is the formula:

$$Tv = \frac{T \times F^2}{F^2 + [e \times n(T-F)]}$$

$$Ta = \frac{T \times F^2}{F^2 - [e \times n(T-F)]}$$

Do not forget that all the quantities used must be measured in the *same* units, inches or feet or yards.

Example: The same conditions as in the preceding example:

$$Tv = \frac{20 \times 12 \times 2^2}{2^2 + [1/750 \times 8(20 \times 12 - 2)]} = \frac{750 \times 960}{4904} \text{ in.} = 12\tfrac{1}{2} \text{ ft.}$$

$$Ta = \frac{20 \times 12 \times 2^2}{2^2 - [1/750 \times 8(20 \times 12 - 2)]} = \frac{750 \times 960}{1096} \text{ in.} = 55 \text{ ft.}$$

Comparison with the previous calculation will show that the results are more or less the same as those obtained using the hyperfocal distance method. With the help of this formula anyone can work out for himself a depth of field table for his own camera. Be careful to use the correct tolerance for the circle of confusion.

FOCUSING

Focusing can be carried out on a ground glass screen; by estimation or measurement and using the focusing distance scale; or alternatively by using a distance meter or rangefinder. Focusing on the ground glass is carried out at full aperture, afterwards stopping down. Where focusing is done by setting to a scale of distances, it is good enough just to estimate the distance, especially when it is desired to photograph relatively distant objects.

For nearby objects the distance ought, however, to be determined with rather

greater precision, more particularly so for very short distances and larger apertures.

For focusing with a rangefinder the depth of field needs to be watched. It is easy to imagine that with a precise instrument of this type it is good enough to set the focus on the exact distance to get a sharp negative. But in this case also it is essential not to forget what has been said about the depth of field, and that the manufacturers have good reasons for providing depth of field indicators engraved on the focusing rings on the lens mounts.

If the subject is such that one wishes to reproduce the foreground sharply as well as objects at a distance, the stop necessary can be found by reference to the formulae given above or by consulting a depth of field table.

Parallax

The field framed in the viewfinder does not always exactly correspond with the image in the camera. Where the viewfinder is placed well above the lens and the subject is, say, a bird being photographed close-up so that it fills the frame, then it is very likely that the negative will show an image of the bird with the

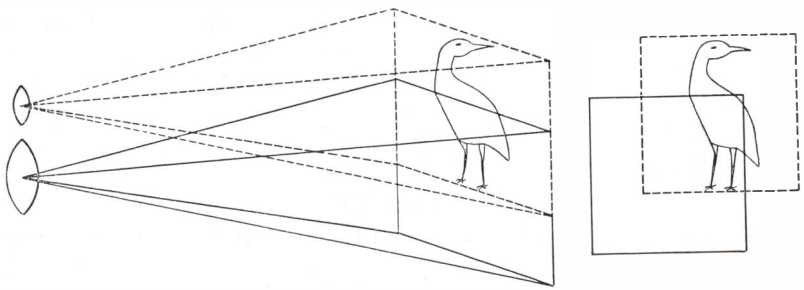


Fig. 23

head cut off. Fig. 23 shows clearly how this comes about. Although the whole bird is shown in the finder the negative only records the bottom portion. This discrepancy is greater if the viewfinder is placed not only above the lens but also to one side (see fig. 23 right).

This is called *parallax*. It only matters in practice in close-up photography. In most cameras the finder is found to be as close as practicable to the lens and some modern cameras are provided with a parallax adjustment on the viewfinder which eliminates this trouble (parallax compensation). Single lens reflex cameras with a retractable mirror are completely free from parallax.

The rangefinder (viewfinder)

Quite a number of modern miniature cameras (24 × 36 mm.) and some roll film cameras are equipped with coupled rangefinders.

There are many different designs, but the principle is more or less the same

Photo: K. Hutton →



for all. The object is viewed through a semi-transparent 45° mirror. A second 45° mirror placed an inch or so to one side, reflects on to the first mirror a second image of the same object. The two images are seen to coincide if the object is at infinity, but if it is nearer the two images are displaced one from the other and the position of the second mirror has to be altered slightly to bring them into coincidence once more. The amount of adjustment required to effect this can be used to measure the object distance.

The rotation of the movable mirror is usually transmitted to a lever which in turn moves a pointer over a scale of distances. Generally this movement is coupled to the lens mount itself in such a way that the lens is automatically focused (coupled rangefinder). The accuracy of the meter is dependent very much on the separation of the mirrors S_1 S_2 and is higher when they are wider apart.

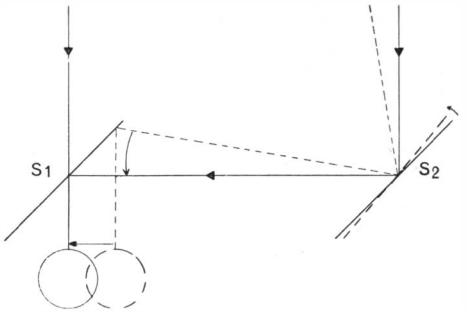


Fig. 24 The eye sees the object directly through the mirror S_1 and by reflection from S_2. Mirror S_1 is fixed. Mirror S_2 can turn about its centre. When the subject is at infinity the two images in S_1 coincide, but if the object is closer the reflected image from S_2 is separated from the direct image seen through S_1. This separation increases as the object moves closer. To bring the two images back into coincidence mirror S_2 has to be rotated on its axis. This rotation is transmitted by a mechanical link, either to a pointer or to the focusing lens mount.

Silvered mirrors can be used, sometimes one or both are gold coated, when the transmitted image is greenish, while the reflected image is reddish. This colour difference helps in making an exact coincidence setting.

SHUTTERS

Every point on the object radiates light in all directions (see fig. 4). The lens collects a bundle of these rays and converges this bundle to a point. The opening in the diaphragm forms the base of the cone of rays. In this way the stop diameter controls the intensity of light falling on the sensitive material. The quantity of light, however, depends also on how long the cone of light is allowed to act on the emulsion. This time is regulated by the shutter.

The shutter is worked either by pressing a button or a lever, and a flexible cable release may also be used. The cable release is screwed into a standard socket in the shutter housing or in the release button. To avoid camera shake it is advisable to use for time exposures a cable release of about 10 in. long.

The photographer can include himself in the picture by using a delayed-action release incorporated in the better cameras on the market today; however, accessory self-timers are available for all cameras. After setting the self-timer the shutter only goes off after a delay of 15 to 20 seconds, so that the

photographer can include himself in the picture in the place determined beforehand.

There are two kinds, lens shutters and focal plane shutters. Their names describe their distinguishing features.

★ Lens shutters

Lens shutters are placed in front of or just behind the lens, sometimes close to the diaphragm.

(1) *Roller Blind Shutters.* The best known shutter of this type usually placed in front of the lens is the roller blind shutter. This shutter, mostly but not exclusively used on the larger sizes of camera, has a black fabric blind which is provided with a rectangular slit or aperture. This curtain is fastened to two spindles, the lower one being tensioned by a coil spring. By rolling the blind up on the top spindle the spring is wound up and immediately the release is pressed the toothed ratchet wheel, seen on the left, is set free and the curtain moves from top to bottom. The exposure is made as the rectangular slit passes the circular opening in the body which fits over the lens (they can be used behind the lens). Usually the roller blind shutter can be regulated to exposure times of between 1/15th and 1/90th second and time exposures.

(2) *Bellows Shutters* are placed behind the lens and are now rarely seen, except on large portrait cameras. It is made of two spherical bellows of black fabric fastened behind the lens inside the camera. The bellows are opened by mechanical (bowden-wire) or pneumatic action (air piston). They open silently and invisibly, which is an advantage for portraiture, although they sometimes close noisily. If far to the rear of the lens they may expose the centres of the plate more than the edges, this edge vignetting is considered desirable or goes unnoticed in portraiture.

(3) *Between-the-Lens Shutters.* These shutters, which are generally placed very close to the diaphragm, are in fact those in most common use. They are made of thin blades of metal or plastic, sickle shaped, which slide over each other. Under the action of a spring the leaf blades turn and open from the centre to the edge. They can usually be set on T (Z on some German types) – Time, one pressure for opening and a separate one for closing; on B – Bulb, one pressure for opening, closing on release of this pressure and on a range of instantaneous times from one second down to 1/500th second. The best known shutter of this type is the Compur, which is driven by a train of gears with a clockwork retard. It has replaced, at least in the smaller sizes, the Compound (with a pneumatic retard) which was far less accurate. Most between-lens shutters have to be pre-set or 'cocked' before use.

During recent years between-the-lens shutters have been considerably improved. The presetting or cocking of the shutter is now usually coupled with the film transport mechanism in such a way that the two operations are done at one and the same time. The release lever is mounted on the camera body to prevent camera shake, thus assuring clear images.

To prevent making two exposures where there should be only one the film in modern cameras has usually to be wound on before a further photograph can be taken, there being a mechanical arrangement to prevent what is known as 'double exposure'.

On several of the latest cameras the shutter speed settings are coupled to the diaphragm settings, such cameras use a *light value scale* for the setting of the correct exposure. This will be mentioned further at the end of this chapter. Synchronization of the shutter with flash guns is dealt with in Part II.

(4) *Section Shutters.* In their simplest form these shutters have a blind with an opening which is larger or at least as large as the maximum diameter of the lens.

The simple guillotine or drop shutter is worked by its own weight. The rotary shutter is made to work thanks to the action of springs so that the lens is uncovered, the exposure time being determined by the speed of the rotating disc. In modern types there are two blades, one which uncovers the lens while the other covers it after exposure. Everset shutters belong to this category. As implied by their name, no pre-setting or cocking of the shutter is necessary. It should be noted that in all guillotine-type shutters the opening remains the same, the exposure time depending on the speed of rotation of the blade. The blade is usually placed as close as possible to the lens. A high efficient type of rotary shutter is that fitted on the Robot camera: it is set in motion by a motor so that it is possible to make series of exposures (4 or 5 per second)

by merely pressing the release, the release having to be pressed only once. In this camera the motor takes care of the shutter mechanism, the automatic transport of the film as well as the counter mechanism.

★ Focal plane shutters (or slit shutters)

The shutters that have been described all have in common the feature that they only open and close gradually, but since they are at the lens the image nevertheless appears complete on the ground glass immediately they start to open (see also shutter efficiency, p. 40). The focal plane shutter works in a completely different way. Light falls on the emulsion through a slit which moves from side to side across and close to the sensitive surface. The full aperture is consequently called into play immediately but the image is only exposed successively strip by strip and not all at once.

This being so, we should distinguish between the exposure time at any given point and the total time during which some part of the plate is being exposed. The first is the time taken for the light from the slit to pass over any given point, the second for the light to travel from one end of the plate to the other. If, for instance, the slit width is 1/10th of the plate width and the total exposure time is 1/100th second, the point exposure time and consequently the effective exposure time, assuming full efficiency, will be 1/100th second. Photography of subjects moving at high speeds with this type of shutter often produces characteristic distortions in the image: if the slit moves from top to bottom the lower part of the image, and hence the upper part of the subject, are recorded after the top. As a result a racing car, for instance, photographed on the optical axis of the lens seems to be leaning forward, circles are distorted into ellipses and straight lines are curved. This fault is avoided by placing the slit vertically and running it in the same direction as the car because the image moves in the opposite direction to the subject and hence the shutter and image have the greatest possible relative velocity. This is why many modern press cameras are provided with reversible shutters. In using this type of apparatus it should be remembered that a slit operated horizontally travels more slowly than if made to move from top to bottom. The speed of travel is even slower if the slit travels upwards.

Another feature of the focal plane shutter is that the blind slit travels more slowly at the start. The first part of the image is, therefore, more fully exposed than the last part. This particular property can be advantageous in landscape work where the foreground is generally less well lit than the sky. For subjects moving at high speeds it sometimes gives rise to blurring in the lower part of the picture. This difficulty can be overcome somewhat by increasing the spring tension. It is better, in general, to open up the slit and to increase the spring tension rather than the opposite. The focal plane shutter consists in principle of a blind which is wound on two rollers, one on each side. As the blind is wound on to one of the rollers it winds up a spiral spring attached to the other roller. The curtain or blind is provided with a gap or slit the width of which can be adjusted. This simple arrangement is suitable for a reflex camera where the sensitive material is protected from light as the shutter is wound up by dropping the mirror, the two actions often being interlocked. When used in other types of camera the mechanism is much more complicated. Two superimposed curtains or two parts of the curtain travel in the focal plane slit in such a manner that the slit is kept closed or covered while the shutter blind is rewound and the spring retensioned. The blind must work as close as possible to the sensitive surface or the top and bottom of the plate will be less exposed. This becomes more important when narrower slits are used. Focal plane shutters have the advantage compared to in-between-the-lens shutters in that the lens can be interchanged without needing a separate shutter for each lens. In addition they have a greater versatility in that speeds of 1/1000th or even 1/2000th second can be obtained with them. Between-the-lens shutters on the other hand, while slower, are free from the characteristic image distortions described above.

★ Shutter efficiency

Between-the-lens shutters open from the centre to the periphery and close towards the centre from the edge. These movements need a certain time to take place, and it follows that the lens is not completely uncovered for the whole duration of the exposure. The ratio between the amount of light which effectively passes through the lens and the amount that would have



Photo : Dorothy Hope-Smith

fallen on the sensitive surface if the shutter had been fully open for the whole duration of the exposure is a measure of the shutter *efficiency*. For any given shutter the *efficiency* increases as the aperture is closed and the time of exposure is lengthened. The distance to be travelled by each sector being reduced as the aperture is closed, the shutter therefore reaching the fully open position quicker, and the time taken to do so taking up a lower proportion of the total time as this is increased. The efficiency of between-the-lens shutters is generally between 50 to 60%. Some modern types can reach about 80%. With focal plane shutters the efficiency primarily depends upon the distance between the slit and the sensitive surface. This separation ought to be as small as possible. A good shutter of this type can reach a maximum efficiency of 90 to 95%.

★ Shutter testing

Agreement between the stated shutter speed and the effective shutter speed is rarely achieved. Often, however, accurate exposures are essential. It is advisable, when there is any doubt, to check the shutter speed. There are many ways of doing this.

If you have a gramophone with one of the new motors that give $33\frac{1}{3}$ and 78 revolutions per minute, you will be able to check all the speeds from 1/50th to 1 second: fasten a circle of black card, about 10 in. diameter, to the turntable with a strip of gummed paper – or better still, use a blank record disc. Now stretch a length of white cord from the centre to a point on the edge along a radius. Mount the camera to be checked vertically over the turntable as close to it as possible so that the disc fills the whole of the negative frame (use a close-up lens if your camera will not focus to such a short distance). On each side set up a photoflood or a 500-watt lamp at about $2\frac{1}{2}$ ft. Load with a high-speed panchromatic film (such as 'Gevapan 36') and make exposures as shown below.

Turntable Speed	*Shutter Speed*	*Stop Value*
r.p.m.	seconds	
$33\frac{1}{3}$	1	*f*/22
78 or $33\frac{1}{3}$	1/2	*f*/22
78	1/4 or 1/5	*f*/16
78	1/8, 1/10, 1/15	*f*/11
78	1/25 or 1/30	*f*/8
78	1/50 or 1/60	*f*/5·6

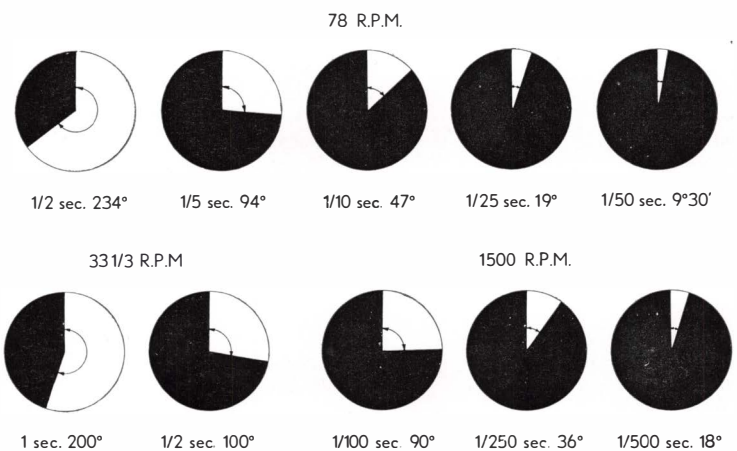


Fig. 25 Diagram illustrating theoretical values of certain shutter speeds.

For speeds shorter than 1/60th second it is advisable to remove the turntable and mount the black disc directly on the motor spindle by means of an adaptor ring. Motors of this type usually have a spindle speed of 1,480 to 1,500 revolutions per minute which can easily be checked with a rev-counter. In this way the remaining two shutter speeds can be checked by making a series of exposures with the diaphragm opened up to compensate for the shorter times as follows:

Disc Speed r.p.m.	*Shutter Speed* seconds	*Stop Value*
1480–1500	1/100 or 1/125	*f*/4·5
1480–1500	1/250	*f*/3·5
1480–1500	1/300	*f*/2·8–3·5

Develop the exposed film in a high contrast developer such as 'Metinol U'. After fixing and washing, examine the film and you will find that you have a series of negatives each of which shows a clear disc with a black sector of varying angles. These angles can now be measured with a protractor laid on the negative and compared with the theoretical values. At the same time, to get a more accurate result, you can enlarge the negatives and make the measurements on the print, or measure the enlarged image projected on to a white card on the easel. This will give you all the information you want; a print is not really necessary.

The speed figures are worked out as follows: the normal turntable speed is 78 r.p.m., so in one second it rotates through $\frac{78}{60} \times 360°$; i.e. 468°.

From this we can say that:

A shutter speed of 1 second at 78 r.p.m. should give an angle of 468°
,, ,, ,, ,, 1/2 ,, ,, ,, ,, ,, 234°
,, ,, ,, ,, 1/4 ,, ,, ,, ,, ,, 117°
,, ,, ,, ,, 1/5 ,, ,, ,, ,, ,, 94°
,, ,, ,, ,, 1/8 ,, ,, ,, ,, ,, 58° 30′
,, ,, ,, ,, 1/10 ,, ,, ,, ,, ,, 47°
,, ,, ,, ,, 1/15 ,, ,, ,, ,, ,, 31° 10′
,, ,, ,, ,, 1/25 ,, ,, ,, ,, ,, 19°
,, ,, ,, ,, 1/30 ,, ,, ,, ,, ,, 15° 30′
,, ,, ,, ,, 1/50 ,, ,, ,, ,, ,, 9° 30′
,, ,, ,, ,, 1/60 ,, ,, ,, ,, ,, 7° 50′

In one second at 33⅓ r.p.m., the turntable rotates $\frac{33{\cdot}3}{60} = 0{\cdot}55$ times, or $360 \times 0{\cdot}55 = 200°$ and in 1/2 second, 100°. For the faster speeds, at say 1,500 r.p.m., and 24·66 r.p.s., the angles are: for 1/100 second, 90°; for 1/125 second, 71° 10′; for 1/250 second, 36° and for 1/500 second, 18°.

To boil all this down into practical terms, treat your results as follows:

If your shutter set to 1/10 second gives an angle of 35° instead of the theoretical 47°, this shows that it has been open for only $\frac{100 \times 35}{47}$ – i.e. for only 75% of the indicated time, and the exposure was 25% short. To put matters right, you would have to open the lens up a quarter of a stop.

With some cameras it is possible to set the shutter to intermediate speeds (see the directions for use of your camera).

This method is fairly complex, but has the advantage of being accurate; the following is simpler and is for most cases sufficiently accurate.

Turn a bicycle upside down to rest on the saddle and handlebars. Stick a piece of white paper or something bright on one of the tyres. Give the wheel a turn. When it is revolving at one revolution a second photograph the whole wheel. The piece of white paper will show up on the negative as a band of density from which the effective exposure time can be calculated. If the length of the density track made by the piece of paper is 1/10th of the circumference the exposure time is 1/10th second.

The exposure

Keep the camera still when taking the picture. For a time exposure use a firm tripod. For short exposures a chain with one end screwed into the tripod socket on the camera, the other held to the ground by a foot and held taut, gives excellent results. Unipods and chest supports can also be used. For exposures on a tripod use a flexible cable shutter release and keep still and do not cause any disturbance during the exposure. If the camera vibrates or shakes as the shutter is opened it is a good idea, if the exposure is a long enough one, to hold a piece of black cardboard about $\frac{1}{4}$ in. in front of the lens for a moment or two to allow the apparatus time to settle down.

As a general rule do not try or use times longer than 1/25th second without holding the camera on a rigid support, 1/100th second for best results with a precision miniature camera. Using a unipod or chain support it is possible with a little practice to give exposures of 1/5th, or 1/2 or even 1 second duration.

DECIDING THE EXPOSURE TIME

When the aperture and negative material to be used have been settled the exposure time depends on two factors, the quantity and the nature of the light reflected by the subject. These two factors are in their turn determined by the time of year, the time of day, the weather, the position of the subject relative to the light, the colour and the relative brightness of the subject.

It is necessary to take all these factors into account in deciding the exposure time. Straightforward evaluation, moreover, itself difficult and uncertain, often results in large variations in exposure between the different negatives on a single roll of film. It is true that serious variations in exposure can often be corrected by a judicious choice of paper and paper exposure, nevertheless the best results are obtained with as exact a determination of the exposure as is possible. To assist in doing this either exposure tables or exposure meters (photometers) can be used.

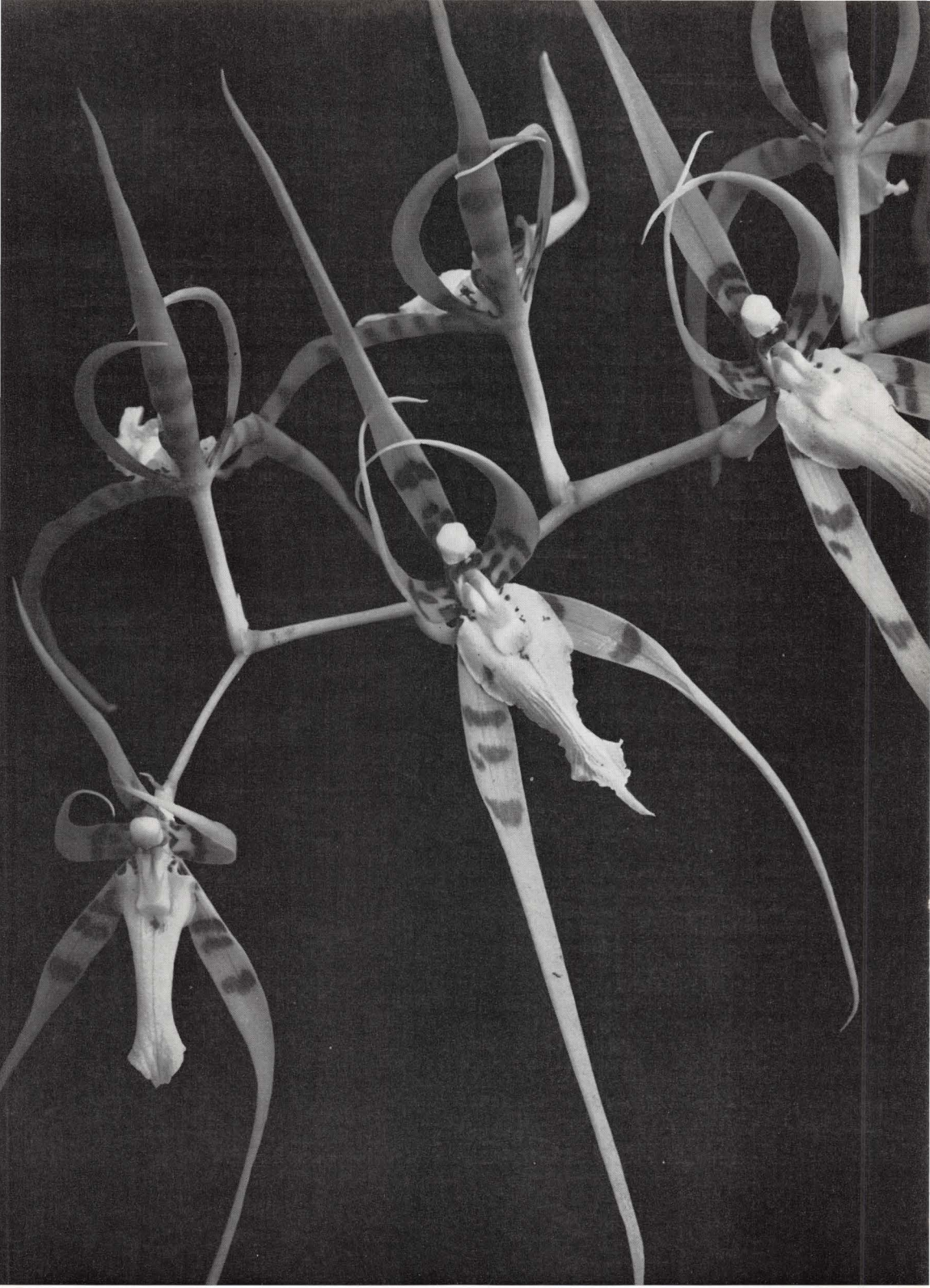
Exposure tables

Exposure tables can only give approximate results since the evaluation of certain factors, say, for example, the weather, varies so much from one person to another and however well tables gauge some conditions, they cannot cover all. Approximate values are, however, acceptable since the negative material used has generally sufficient latitude to accommodate normal inaccuracies. Gevaert publish for amateurs (both still photographers and cinematographers) extremely practical exposure tables. There is similarly an exposure table for 'Gevacolor' films. These tables will be sent on request.

Photometers

Photometers giving the exposure can be used to measure either the light reflected by the subject or the light incident on the subject. There are three main

Photo: Steef Zoetmulder →



types of photometer, chemical (actinometers), optical and photoelectric. Chemical photometers (actinometers) in which the time of blackening or darkening a strip of sensitive paper measures the light intensity are no longer in everyday use.

★ Optical exposure meters

Most optical exposure meters consist basically of a grey or blue step wedge of increasing density through which, when directed towards the subject, can be seen a series of numbers. In the first type of optical meter the object is observed through the glass while it is turned by a ring until the details in the darkest shadows just disappear. The position of the ring, indicated by an arrow reading against a graduated scale, then gives the reading of the exposure to be used. In the second type the photometer is pointed directly towards the shadows of the subject. Light falls on the glass wedge showing up a graded array of numbers. The last figure to be just readable gives on a table the exposure to be used.

There are as well other systems varying somewhat from the two types described, but used much less frequently. Compared with chemical photometers (actinometers) these optical exposure meters have the advantage that they indicate the exposure required more rapidly. The reading obtained varies from one individual to another but is reduced by practice and experience. Note that the method of use prescribed in the instructions supplied with the instrument must be adhered to. Some manufacturers specify, and have good reasons for doing so, how long to wait before reading the number which appears last on the photometer. This precaution is of great importance in using them correctly.

★ Photoelectric exposure meters

This type of exposure meter is based on a photosensitive cell which converts light into electricity. The original meters of this kind were bulky, fragile, and difficult to keep working accurately. They have now become a highly specialized instrument – the barrier layer photoelectric exposure meter. The cell comprises a small metal plate coated with a thin layer of selenium about 4/1000 in. thick. This layer in its turn is coated by vacuum deposition by a thin transparent layer of gold or platinum (counter electrode). When light falls on it the selenium layer liberates electrons which, when a circuit is completed between the metal layer and the counter electrode, causes a current to flow sufficient to produce a deflection in a very sensitive galvanometer which is proportional to the light intensity. It should be noted, however, that the proportional relation between the photoelectric current and the light intensity only applies for a particular galvanometer resistance (normally 10 ohms). Although some six times more sensitive than the copper oxide cells hitherto used the selenium cell only works when the illumination exceeds a certain minimum luminous intensity. Direct sunlight will generate a current of several milliamps. To keep the galvanometer scale as short as possible photoelectric exposure meters are generally provided with a resistance which is only brought into the circuit when the light is bright. Some meters use an optical grid or perforated plate to reduce the light falling on to the cell by a fixed fraction, say 1/16th of that incident on the meter, and use a different scale leaving the galvanometer circuit unchanged. For dim light.

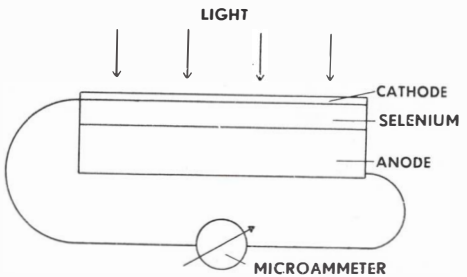


Fig. 26 Principle of the barrier layer photocell. Light falling on the selenium layer liberates electrons and causes a current to flow when an external circuit is complete.

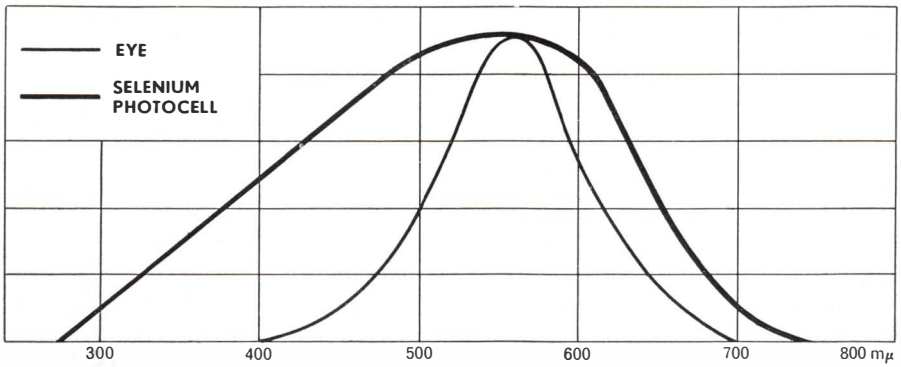


Fig. 27 The colour sensitivity of the selenium cell is very close to that of the human eye.

such as interiors or in artificial light, the resistance, or restricting baffle, is taken out of the circuit, or light beam.

Besides its high overall sensitivity the selenium cell has the advantage of responding to the different colours of the spectrum in a manner very close to the response of the human eye. Its maximum sensitivity for red light is closely similar to that of the eye, as well as that of panchromatic emulsions, as mentioned later.

Towards the shorter wavelengths (violet and ultra-violet), however, the selenium is very much more sensitive, but the necessary correction is so small that it can be more or less neglected.

How should an exposure meter be used?

It is very often thought, quite erroneously, that a photoelectric exposure meter will *automatically* indicate the correct exposure required. This, however, is rarely the case. The correct method of using the meter must be known if correct results are to be obtained. There are two methods of working:

Either (1) The meter is pointed towards the subject; in this case the *reflected* light is measured;

or (2) The meter is pointed towards the camera (or more properly the main light source). In this case the light falling on the subject is measured, i.e. the *incident* illumination.

★ Measurement of reflected light

Usually the exposure meter is directed towards the subject from a position near the camera. So long as there are no extreme contrasts of light and shade in the subject the reading can be taken to be correct. This is due on the one hand to the fact that the meter is calibrated by the manufacturer on a grey of average reflectivity (10–15% reflectance) very close to the mean value, for an average subject, between the highlights or brightest parts and the darkest parts of the subject; and on the other hand to the fact that for a subject of low or medium brightness range, because of the latitude of the negative material, a range of exposures can, in principle, be considered 'correct'. It will readily be seen that the exposure meter measures only the total reflected light and cannot, when the

subject is of marked contrast, take account of the nature of the subject as can the operator. If, for example, a figure is placed in front of a white wall or a clear sky, the background affects the exposure meter far more than the subject will, and it will indicate an exposure adequate for the background but far too small for the subject proper.

This defect can be got over by making the measurement from the subject itself, in the example above from the face of the person. To do this the exposure meter is held at a distance no greater than the shorter dimension of the subject: 6 in. from a face. Care should be taken that no shadow of the meter or the hand falls on the subject. The exposure meter will then show the correct exposure for the face. If more detail is desired in dark clothing the exposure must be accordingly increased. If necessary a second measurement can be made, this time on the darkest parts, and a suitable mean between the two readings can be used to determine the exposure.

For open landscapes with overcast sky it is advisable to incline the meter downwards towards the landscape and not towards the sky. This precaution is unnecessary with a clear sky, this being in actual fact no brighter than the sunlit landscape.

In making the measurement it is just as important to make allowances for reflections, e.g. from water, snow, asphalt, pavements, windows, etc. Unless this is done under-exposure will inevitably result. It is best to avoid strong local reflections, and when the reflection is weak but large in area, to make the measurement from a grey (or white) card or from the hand as described below. The incident illumination could just as well be measured, but this method will be dealt with later.

As was stated at the beginning of this paragraph, exposure meters are generally calibrated by the makers on a medium-grey. If a subject is to be tackled that is lighter than this medium-grey (sand dunes along the shore, or a landscape under snow without any appreciable shadows) the exposure indicated by the meter may very well be reduced by half; if, on the other hand, the subject appears very dark the exposure should be doubled.

It was suggested above for portraiture that the meter should be pointed towards the face of the subject and that the exposure so found should be used. If, however, it is desired to work more carefully as, for example, is necessary with colour film, an allowance must be made for the fact that the face has generally about twice the reflectance of the mid-grey for which the exposure meter is calibrated.

In order to give the same level of exposure that would be obtained if the measurements had been made from the medium-grey we must, therefore, double the indicated exposure. This will also be the case when the reading is taken from the hand, for example when the subject is difficult to get at. The hand must obviously be illuminated by the same light (the same intensity from the same direction) as the subject itself. A piece of white matt paper will do just as well (white blotting paper). In this case the exposure must be multiplied by five (5×) or thereabouts (or the aperture opened a little more than two complete stops).

It is important to remember the following rule, which is frequently lost sight of. In determining exposure it is correct to base this on the shadow areas for negative films and on the highlight areas for reversal films. The measurements discussed above ought, therefore, to have been made for negative film in the shadow parts of the subject and for reversal films in the highlight (brightest) parts of the subject. When, however, the shadow detail is not considered to be of any great importance (compared to the highlights) the exposure meter can be pointed at the principal object in the scene.

When working with a subject of great brightness contrast range, e.g. 1 : 500, and if, above all, the highlight separation is to be preserved, then the shadows should be ignored, even if working with negative material, and the meter be directed towards the highlights (see what is said later on about subject brightness contrast range).

★ Measurement of incident illumination

As has already been said, with this method, the meter is not pointed towards the subject but towards the camera in line with the optical axis. In this way light reflected by the subject is not measured, but only that falling on the subject, the incident light. Several modern makes of exposure meter can be used for both types of measurement, provided the makers' instructions for their use are strictly followed. There are a considerable number of different systems: in one type the honeycomb cover is removed, in another a slotted screen is closed, in yet another a cowl or disc is placed over the cell. There are collectors that are flat, others that are hemispherical or conical and receive all the incident light whether it is from the front or the side.

When using the type with the hemispherical diffusing front attachment, the meter is usually pointed towards the camera from the position occupied by the subject. When using the type with a flat diffuser the meter is pointed midway between the direction of the camera and that of the sun. If the subject is dark in tone an aperture a half or a whole stop wider than that indicated by the meter should be given (e.g. *f*/5·6 instead of *f*/8). If the subject is light in tone close down the aperture indicated half a stop. For subjects of great brightness range (contrast) the measurement is best made in the shadows.

★ Measurement of brightness ranges

By brightness range is meant the contrast between the darkest shadows and brightest highlights (not specular highlights) of the subject.

To determine this contrast with an ordinary photoelectric exposure meter, a measurement is made, from as close as possible, of the brightest and the darkest parts of the subject. The contrast or brightness range is the ratio between the two values so measured. With optical telephotometers, the brightness of any part of the subject can be measured from the camera position, the acceptance angle of the instruments (S.E.I. photometer) being very small (about half a degree). From these measurements and a knowledge of the latitude of the film

or plate, it is possible to deduce to what extent the negative material will be capable of recording accurately the extremes of brightness. Those readers who are interested in pursuing this subject further should refer to what is said on page 61 concerning contrast and exposure latitude. In Part IV this matter is discussed more particularly as it concerns the use of colour film.

The brightness range of interiors can easily be brought under control if the light sources can be adjusted to do so. On the other hand it is rarely possible to alter the ambient daylight very much. When the subject is of a reasonable size it is possible to reduce the contrast by illuminating the shadows by making use of reflectors, of diffusing screens, or of flashlight.

★ Exposure for close-up macroscopic photography

For close-up photography the exposure required is predominantly governed by the bellows extension. The correction to be applied is given by the formula $(M+1)^2$ where M is the magnification of the subject.

Example: If the ground glass image is twice the size of the original then the exposure should be increased by $(M+1)^2=9$ times.

This formula can equally well be applied to values of M less than 1, that is for reductions.

Example: The ground glass image is 2 in. high, the subject itself 20 in. In this case the magnification ratio is $2/20=1/10$ and the correction factor is, therefore, $(1+1/10)^2=1{\cdot}21$ times. The exposure time for a given stop ought, therefore, to be prolonged by 20%. An increase of this order is negligible in normal conditions. As a general rule it can be taken that the exposure does not need to be increased unless the distance between the film plane and the object is less than 8 times the focal length.

It is not always easy, when using the above formula, to measure the height of the ground glass image (or for that matter the subject) even less so when it is framed in a view finder. In case of difficulty the following formula can be used:

$$\text{F number required} = \text{Normal } f \text{ number} \times \frac{\text{focal length}}{\text{extension}}$$

or better for any given stop:

$$\text{Exposure time required} = \text{Normal exposure time} \times \left(\frac{\text{extension}}{\text{focal length}}\right)^2$$

Example: The exposure meter indicates for a given scene an exposure of 1/10 second at $f/5{\cdot}6$. The focal length of the camera is 4 in. and the camera extension, measured from the diaphragm to the film, is 10 in. What exposure ought to be given?

If only the aperture is to be changed the formula above gives:

$$f \text{ number required} = 5{\cdot}6 \times \frac{4}{10} = f/2{\cdot}24 \text{ at } \frac{1}{10} \text{ second.}$$

If only the exposure time is to be changed:

$$\text{exposure time required} = \frac{1}{10} \times \left(\frac{10}{4}\right)^2 = \frac{5}{8} \text{ at } f/5{\cdot}6 \text{ or a little over } \tfrac{1}{2} \text{ second.}$$

★ Notes

1. All good makes of exposure meters are sold with an instruction leaflet which should be read carefully.
2. An exposure meter should be calibrated personally the first time it is used. For this purpose the same subject and the same lighting should be used throughout.

← *Photo: W. Suschitzky*

Example: If the indicated time of exposure for a chosen stop is 1/100th second, make five exposures at the same stop with exposure times of 1/25th, 1/50th, 1/100th, 1/200th and 1/400th second. This procedure ought to be carried out several times in order to give a true average result. After developing the negatives in a standard way (same time, same temperature, same agitation, same tank, same quantity of unused stock developer) examine the negatives (or make enlargements and judge from these) and choose the exposure time which gives the best results and then work out the meter correction necessary to indicate this time.

If, for example, the best negatives are on the average those obtained with twice the exposure indicated by the meter, the speed index used for the film can be divided by half, e.g. instead of using 32 BSI (log.) use 29 BSI (log.), or instead of ASA 125 use about 65 ASA $\left(\frac{125}{2}\right)$.

If, on the other hand, the best negatives are on the average those obtained with half the exposure indicated by the meter a speed index twice that shown on the package can be set on the meter, i.e. 29 BSI (log.) instead of 26 BSI (log.) or 80 ASA instead of 40 ASA.

The exposure is then calibrated for this combination of film and development, and more particularly for the mode of operation chosen.

3. The effective exposure times do not always tally accurately with the times engraved on the shutter. If the results are consistently under or overexposed a simple check on the speeds is advisable, such as the test already described.
4. For 'coated' or 'bloomed' lenses the exposure needed at larger apertures may often be less than that indicated.
5. If a photoelectric exposure meter is given prolonged exposure light it can lose some of its sensitivity. To restore its sensitivity it is generally sufficient to let it lie in the dark for half an hour. If, however, it is left for a long time in bright sunlight the loss of sensitivity may be permanent. The meter should therefore be returned to its case immediately after use.

The light value scale (L.V.S.)

The exposure is generally adjusted on existing cameras in two separate operations: (1) altering the shutter speed; (2) altering the stop.

A number of new cameras use shutters in which the shutter speed settings are coupled to the diaphragm settings so that any adjustment of shutter speed automatically alters the diaphragm in such a direction that the same resultant exposure will be given to the film. If, for instance, the speed is altered from 1/60th to 1/30th second, the diaphragm will automatically be closed one stop from say $f/5{\cdot}6$ to $f/8$. The camera can thus be set so that no matter what shutter speed is determined upon, nor what diaphragm is used (within certain limits), the other setting of the two is automatically adjusted to suit. With such shutters the correct exposure is determined by means of light values.

This 'light value' is the quantity of light that is required to give the emulsion

that is being used, the desired or 'correct' exposure. This is independent of the shutter speed and the diaphragm aperture separately but depends upon their combination. The light value is determined from an exposure meter which has been scaled in light values. New models of meters (Sixtomat, Ikophot, Metrawatt, etc.) are provided with this new scale. To set the camera, all that is necessary is to set the light value pointer to the value on the scale indicated by the exposure meter. In doing this the diaphragm lever alone moves, so that the exposure given will be correct at the shutter speed for which the camera was previously set. If the shutter speed is then changed the stop setting will be automatically changed also. As long as the 'light value' index remains unchanged the exposure given will not vary.

This new system has a further advantage as opposed to former cameras and shutters – the scales for light value shutters and diaphragms are linear, i.e. the distance between adjacent stop numbers and adjacent speed numbers are equal *over the whole range.* The exposure can, therefore, be set with improved accuracy even for intermediate values. The scale of shutter speeds has, however, to be changed to one in which there is a regular geometrical progression. This range of speeds is now:

500 250 125 60 30 15 8 4 2 1

instead of the former series:

500 250 100 50 25 10 5 2 1

On the way to complete automation

The present trend in camera design is increasingly towards the introduction of completely automatic operation.

It is already quite feasible to automate all the various operations which precede the actual exposure. In the latest types of shutters, the rotation of a single control ring links the exposure time and the lens diaphragm openings so that the exposure can be set to the same selected light value (light value : *not* exposure value, as this term is used on the new ASA (Apex) additive exposure system) and at the same time linked to a built-in exposure meter.

When the camera is loaded (with film) the appropriate film speed is set by means of a button (pointer) provided for this purpose.

In the window of the built-in meter (in some cameras, actually in the viewfinder itself) two pointers can be seen. These are brought together, and this automatically ensures the correct exposure.

It is still possible with cameras of this type to readjust the aperture or the exposure time after the correct exposure setting has been made, provided this subsequent adjustment, as in the case of the light value scale (L.V.S.) preserves the same L.V. setting, and remains set to this value since this has already been correctly determined.

With other types of shutter the exposure time is preselected and when the pointers are made to coincide the diaphragm opening is correspondingly changed. In addition there are now some completely automatic equipments,

in these there are no longer any settings for exposure time or for diaphragm openings. All that is needed is to bring the two pointers into line with each other and the shutter automatically chooses the 'best' combination of shutter speed and aperture (programme shutters). Some models even dispense with the need to set anything by hand, not even exposure meter needles, everything is performed automatically.

In some instances the user can no longer make any alterations, in others the automatic mechanism can be disconnected and the normal type of independent hand setting can be used. This completely automatic exposure setting obviously has considerable advantages for the preponderance of ordinary amateur users. They no longer need to think about apertures, settings and similar numbers any more. They then have a camera which will give them guaranteed results, such as they formerly expected with a box camera.

It follows that this guarantee of success applies principally to the greater proportion of 'normal' snapshot exposures, which is what this type of amateur photographer habitually takes. With 'against the light' pictures for example, this type of automatic shutter will obviously be less acurate, particularly when photographing in colour.

The fully automatic cameras have been made as well with fixed focus lenses of rather less expensive types as with adjustable quality lenses normally fitted to miniature cameras.

THE SENSITIVE MATERIAL

In the preceding chapter we have studied photographic optics, and associated matters.

It is just as necessary to have a proper knowledge of the sensitive material. When he knows precisely what is meant by sensitivity, contrast, exposure, latitude, fine grain, etc., the photographer is in a position to be able to influence the final result with a full knowledge of the conditions and with every chance of success.

The aim of this chapter is to deal with these matters in their proper context and to show how good negatives and good positives can be obtained.

THE PHOTOGRAPHIC EMULSION

If a certain quantity of potassium bromide and potassium iodide are dissolved in a solution of gelatine and a solution of silver nitrate is added to the resulting mixture, stirring vigorously all the time, a photographic emulsion is produced.

As the mixing takes place the silver nitrate reacts with the bromide and iodide of the potassium salts to form silver bromide and silver iodide. These crystalline silver salts are not soluble in the gelatine solution. They stay in suspension like particles of butter, fat and cheese in milk. The effect of the stirring is to disperse the suspended salts evenly throughout the solution.

The sensitivity of the crystals of silver salt to light depends on the temperature of the solutions used, on the type and concentration of the gelatine, the amount of digestion (maturing) and the nature and quantities of the dissolved salts.

Digestion is simply the warming of the emulsion for a predetermined time until it acquires the desired photographic properties.

Digestion can be assisted by addition of ammonia to the silver nitrate (a discovery of Van Monckhoven of Ghent). The object of digestion is to make the emulsion more sensitive. The sensitivity can also be increased by the addition of optical sensitizers.

Immediately after digestion the emulsion is allowed to set by keeping it overnight on ice or at a low temperature.

The resulting emulsion is not pure. It contains potassium nitrate and other residual products of the chemical reactions which have to be removed by washing. To do this the emulsion is shredded into small noodles using a special press or something similar. One method in use is as follows: the emulsion is placed in a big silver-plated cylinder perforated with holes; the emulsion is

forced through the holes by means of a piston or plunger and comes out like spaghetti or noodles which are thoroughly washed before being left to drain. The substances to be removed dissolve in the water while the insoluble silver salts (silver bromide, silver chloride) remain in the emulsion.

Next comes the second digestion. The emulsion is remelted and is kept for a predetermined time at a fixed temperature until it attains the desired speed and gradation. Finally a number of special substances are added particularly to

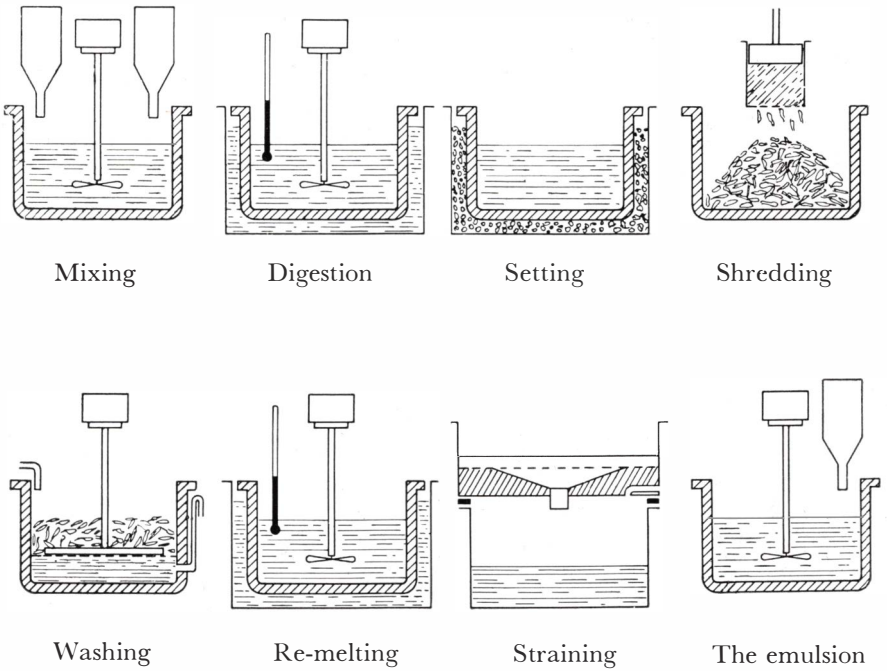


Fig. 28 Making an emulsion, simple diagrammatic form.

improve keeping, to assist spreading, to give the emulsion some special properties or to improve others.

The glass, cellulose, ester and paper supports, before being coated with the resulting emulsion, are given a preparatory treatment. Glass and film base receive a layer of specially prepared gelatine (substratum) to make sure that the emulsion remains firmly attached to them. Paper base on the other hand is coated with one or more layers of baryta (barium sulphate). Barium sulphate is mixed with gelatine and made into a paste and this paste also contains other substances such as dyes (in recent years fluorescing dyes). Baryta coating is not

only intended to promote a good adhesion between the emulsion and the support. The undercoating among other things prevents loss of light in the support and gives to the paper its particular gloss and tint. Usually the baryta coated paper goes through hot calendering rollers which impart a surface smoothness.

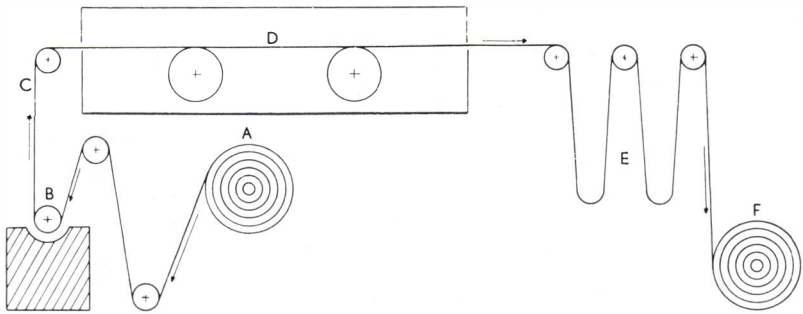


Fig. 29a Coating paper and film base with emulsion (diagrammatic only).

Starting from roll (A) the gelatinized film base (or as appropriate the baryta coated paper base) moves towards the roller in the emulsion tray (B). There a thin layer of emulsion is pushed up by the support. The coated film or paper (C) then passes into a chill box (D) where the warm emulsion sets. Coming out of the chill box the film is automatically suspended in festoons (E) to allow the film to dry properly. The film or paper when dry is finally rolled up (F) and is then ready for slitting.

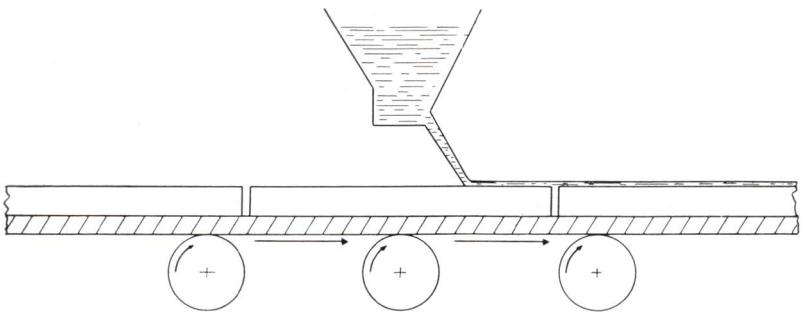


Fig. 29b Coating emulsion on glass (schematic only).

Glass plates are carried on an endless fabric band. As they pass underneath the emulsion flows from a hopper and is spread on the glass in an even layer.

After this operation the support is ready for coating with emulsion. The diagrams above (figs. 29a and b) show diagrammatically how the emulsion is coated. The emulsion was once poured by hand from a jar in a bottle on to glass and paper.

Speed and contrast

The silver salts in an emulsion are sensitive to light, that is when they are exposed to light they undergo a change. The precise nature of this change is not understood very well. We can say, however, that each grain of silver struck by light (a grain is a microscopic crystal of silver salt) acquires a minute black speck called a 'sensitivity speck' or centre. The collection of grains having such specks constitute the 'latent image'. On development the grains with specks on and these only are completely blackened to form the visible silver image.

Some emulsions are much more sensitive than others, i.e. very weak light, or what amounts to the same thing a very brief exposure, is sufficient to form an image. It is therefore necessary, under identical conditions, to give more or less exposure to one material than to another. It is, consequently, necessary to know the sensitivity of any material in use fairly accurately in order that the correct amount of exposure can be given.

It is not, however, quite as easy as might at first appear to measure sensitivity exactly. In fact, sensitivity depends on several factors, and it is not entirely possible to divorce it from other emulsion properties. The matter, as a consequence, lends itself to a variety of different interpretations. As a result there are several methods for determining speed and the speed ratings produced are not consistent, one with another.

Sensitometry is the name given to the study of the different characteristics of emulsions and their effect upon each other, and to research into the best methods of measuring these characteristics (see the condensed résumé in Part VI).

By means of a graph, called the characteristic curve (of gradation or blackening), the science of sensitometry represents the way an emulsion changes incident light into blackening or densities.

We begin fundamentally with the fact that a photographic emulsion that has been exposed to a scene has been subjected at different points, for an equal interval of time, to the action of various intensities of light corresponding to the highlights, the middle-tones and the darkest shadows of the subject. Each one of these light intensities produces, after development, a definite blackening of the sensitive layer which bears a definite relation to the exposure.

The characteristic curve shows graphically how the blackening increases progressively in proportion to the amount of light received sufficiently well for experienced observers to take in the main characteristics of an emulsion at a glance.

How is the characteristic curve produced?

Imagine a rectangular glass plate divided into a number of small rectangles which, from left to right, get darker and darker as if they were covered with thin layers of an appropriate neutral grey. In this way we get a grey scale or wedge (see fig. 30 A). Suppose the first stop is quite clear, the second has a layer of absorbing medium which just lets through half of the light falling on it, the third stop has two layers and so on. The third stop allows 1/4 through, the fourth, 1/8 etc.

If a photographic emulsion is exposed to light through the wedge we shall have, after development, a negative reproduction of the wedge (see fig. 30 B). If the exposure has been well chosen the negative image will show a range of densities running from clear to black through a series of darker and darker greys. These densities can be measured. The luminous intensities corresponding to the

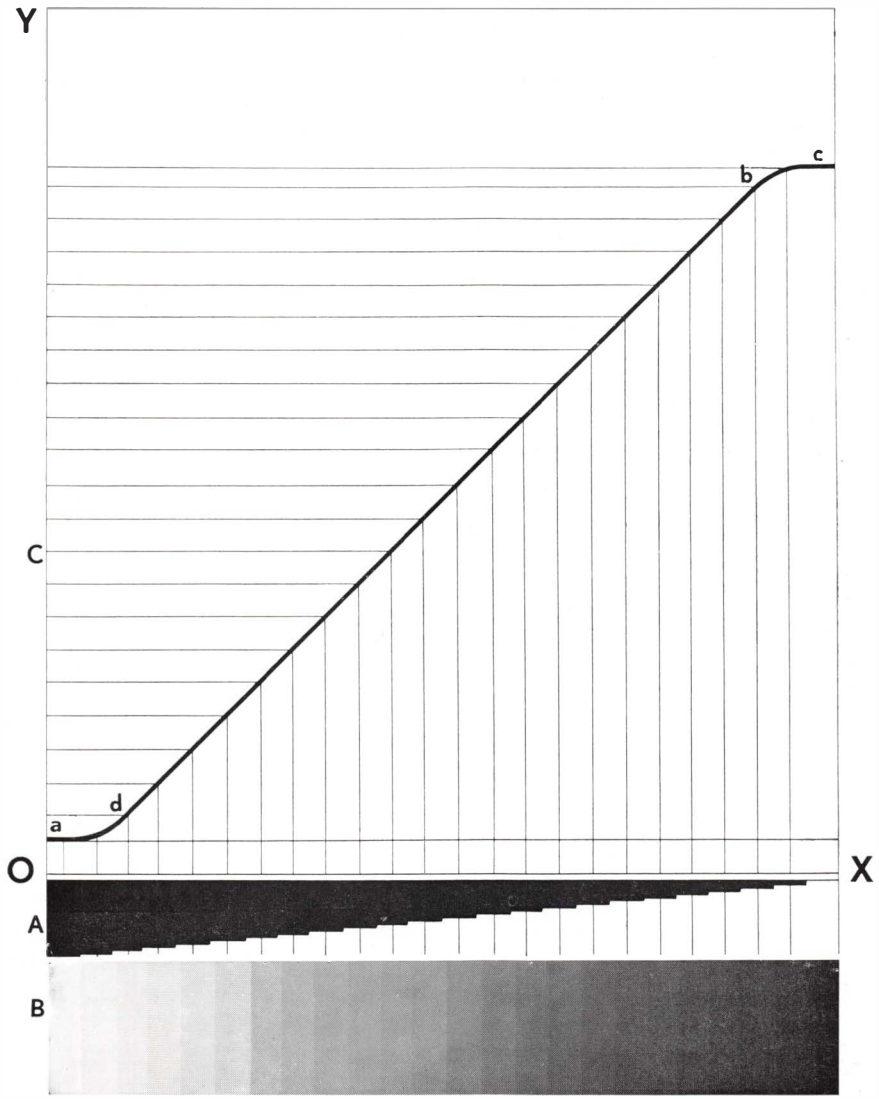


Fig. 30 Construction of a characteristic curve.

original wedge are plotted on a scale OX (see fig. 30). Then along the vertical axis OY are marked the points corresponding to the densities measured in the negative made through the wedge and from these points are drawn lines parallel to OX to meet lines drawn perpendicular to OX from the points marked on OX and so a series of intersections are obtained. A line joining the points of intersection gives the characteristic curve of the emulsion under study.

This curve, on examination, is seen to be made up of a straight line portion *db* and two curves *ad* and *bc*. In the range of the straight line portion *db* the blackening increases proportionally according to the amount of light falling on the emulsion. Over portion *ad* the increase is gradual, over the portion *bc* the blackening decreases more and more until it reaches a point, not visible on fig. 30, where the curve changes direction and where the density *decreases* as the amount of exposure is increased further: this phenomenon is called *solarization*. *db* is the region of correct exposure; *ad* or the foot of the curve the region of under-exposure and *bc* that of over-exposure.

The gamma

We will now compare three characteristic curves with each other (see fig. 31a, b and c). The first thing that strikes us is the fact that these curves have different slopes, that is to say, for equal differences in intensity of exposure (or exposure in a given time) the blackening by no means increases by the same amount.

If the straight line portion of the curve is extended to cut the axis OX and if a line is drawn at right angles to each of the axes OX to cut each curve on the straight line portion we get three lines of length a, a', a''.

The ratio $a : b$ is called the *gamma* (γ) of curve A, the ratio $a' : b'$ the gamma of curve B and the ratio $a'' : b''$ that of curve C. The gamma is also called the *contrast factor*.

The contrast of a photographic emulsion is considered to be *normal* if the gamma is between 0·8 and 1·0 (fig. 31a).

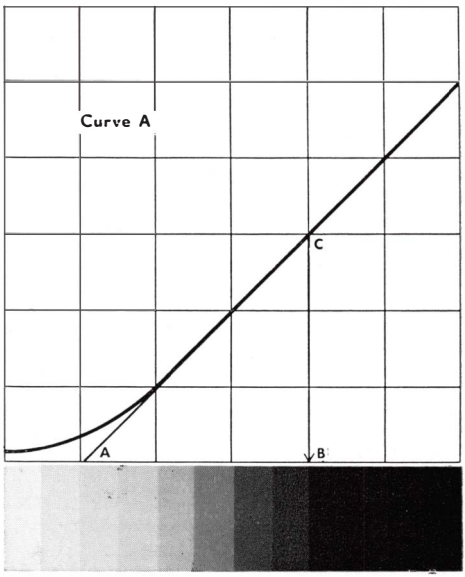


Fig. 31a

A *soft* gradation emulsion has a gamma less than 0·8 (fig. 31b), a *hard* or *contrasty* emulsion a gamma about 1·0 (fig. 31c).

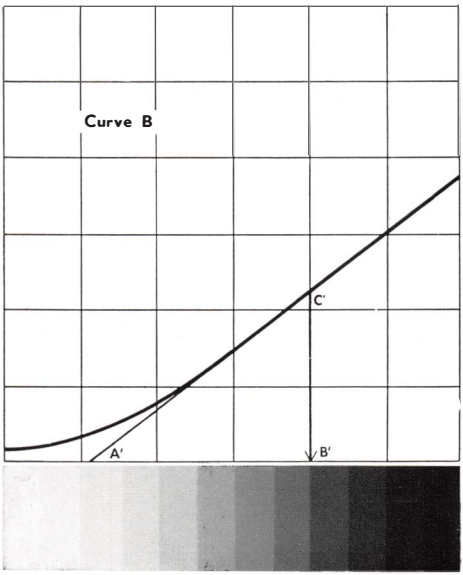


Fig. 31b

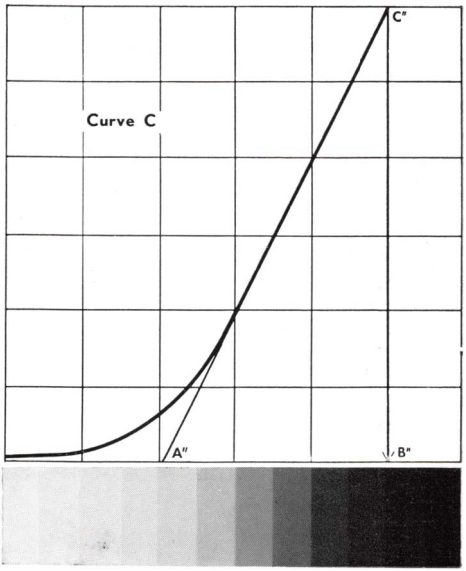


Fig. 31c

Contrast and exposure latitude

The different parts of a scene are photographically distinguished solely by their different brightnesses. In an open landscape, cloudless sky with bright sun, the brightest parts are on the average 50 times brighter than the deepest shadows. The ratio between these brightnesses or the *brightness range* of the subject is, therefore, said to be about 50 to 1.

On a rainy day with an overcast grey sky the brightness range of the same landscape could fall as low as 5 or 6 to 1. The highest brightness ranges occur in interiors—those for instance in which a window appears.

A table is given below for reference of the ranges of different subjects:

Subject	*Brightness Range*
Open landscape, sunlight	25 : 1 to 30 : 1
Open landscape, cloudy	4 : 1 to 10 : 1
Outdoors with foreground, sunlight	30 : 1 to 60 : 1
Outdoors with shadowed foreground, sunlight	100 : 1 to 1000 : 1
Against the light	200 : 1 to 1000 : 1
Landscape with mist	2 : 1 to 4 : 1
Interior, no windows, no reflections	10 1
Interior, windows and reflecting surfaces	up to 1000 : 1
Portrait head, fair hair	10 : 1
Portrait head, dark hair	100 : 1

How does a negative emulsion change such brightness ranges into a corresponding series of densities? Fig. 32 shows the curve of a film of normal gradation. The figures along the horizontal scale give the intensity of illumination (more precisely exposure), those on the vertical scale the densities, or blackening.*

For exposures from 10 to 10,000 the characteristic curve can be seen to be straight. That means that a subject of brightness range of $\frac{10{,}000}{10} = 1000:1$, can, if the exposure is exactly correct, be so reproduced that any density will always bear a constant ratio to the exposure that has produced it. This means as well that a subject of brightness range of only 25 : 1, say a landscape, can be over-exposed $\frac{1000}{25} = 40$ times more than the minimum correct exposure without there being any discrepancy in the relative tonal values reproduced.

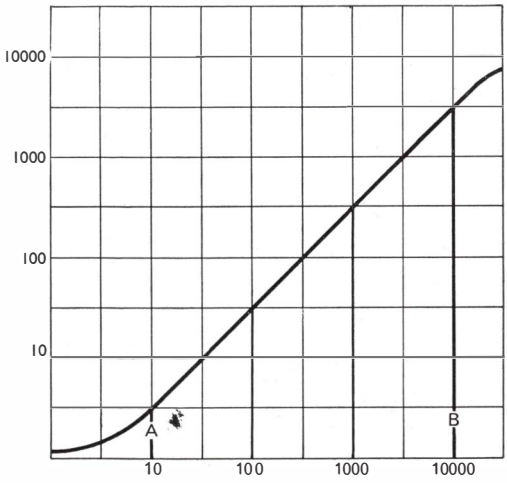


Fig. 32

It is for this reason that AB is loosely termed the region of exposure latitude. This latitude depends not only on the emulsion characteristics but also to a large extent on development. If the time or degree of development is decreased (with a compensating increase of exposure in most cases) the gamma also decreases and the latitude improves. Fig. 33 shows curves for three and five minutes' development. The exposure

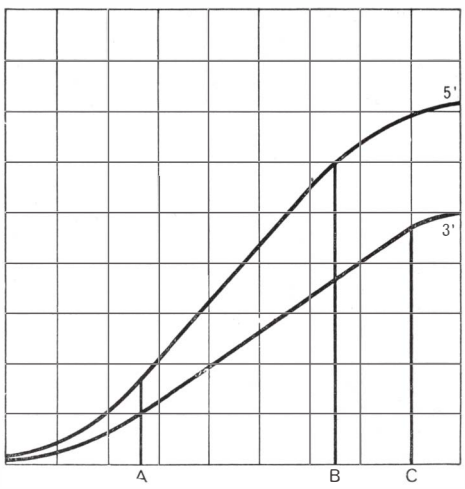


Fig. 33

* The blackening of a negative is generally expressed as the $\log_{10}$ of the *opacity*. If, for example, the opacity of a particular grey is said to be 10 then the grey in question lets through only 1/10th of the light which falls on it.

In this case the density is 1·0 ($\log_{10} = 1$).

The density corresponding to an opacity of 100 is 2, etc.

latitude for three minutes is greater than that for five minutes (AC is longer than AB).

Here is one way a photographer can handle subjects of high brightness range (increased exposure, curtailed development – expose for the shadows, develop for the highlights).

From negative to positive

The aim of photography is essentially to reproduce faithfully the picture seen in the viewfinder or on the ground glass, completely disregarding of course the effects of natural colour, that is in ordinary black-and-white photography.

Here we have a question: what do we mean by a 'faithful' reproduction? To answer this question it is essential at the outset to agree that the image seen on the ground glass is nothing but a collection of light spots of different brightnesses grouped together, some of which are more accentuated than others.

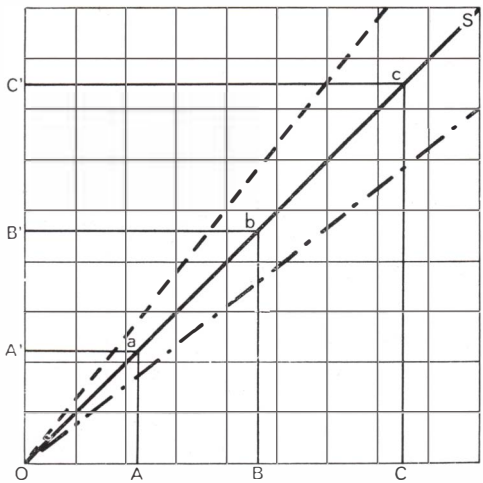


Fig. 34

This being so it can be said that the image is faithfully reproduced if all these spots of light are reproduced just as bright or dark as they are in the original. If this definition is agreed then in order to simplify matters, we can start by only considering the reproduction of a wedge which is itself essentially on a series of such spots (small density patches) which are arranged in a regular order. The ideal positive can, on these considerations, then be represented as the curve of fig. 34. The densities of the wedge are plotted along the horizontal axis and those of the positive along the vertical axis. From this we can go on to say about faithful reproduction that in principle a positive will be regarded as ideal when the brightnesses of the areas which go to make it up are exactly the same as the corresponding areas of the subject. A positive reproduction of a step wedge made by means of an intermediate negative must have step brightnesses which are equal to those of the original wedge steps.

Consider for instance points A, B and C along the horizontal axis and the corresponding points A′B′C′ along the vertical axis. The perpendiculars from these points meet the curve in the three points *a*, *b*, *c* and a line joining these and continued to the horizontal axis gives the line OS which is the tone reproduction curve for the ideal positive.

Closer examination shows that in moving one division to the right the curve also rises by one division. In this case we can say that the 'gamma' of the curve equals 1. If, however, the curve rises more steeply, as does for example the dotted curve, the gamma is greater than 1. The print is then said to be more contrasty than the original. The gamma is less than 1 for the dashed curve and the print is, therefore, softer than the original.

The ideal positive

Now the question is how is it possible in practice to make this ideal positive?

It would seem at first that the method has been already outlined. First expose and develop the negative so that all the tones fall on the straight line portion of the curve, then have only the straight line portion of the curve used when enlarging or printing and choose the contrast of the positive material so that it compensates for any departure from gamma 1 that may have been introduced at the negative stage.

POSITIVE MATERIALS

However, in practice, unfortunately, this cannot be done, since the positive material most used – paper – will only meet these requirements in a very limited number of cases.

A preliminary word of explanation is necessary here.

In dealing previously with negative blackening we have observed that with good plates and films we can, because of the length of their straight line portion, photograph subjects of high brightness range (contrast) so that the increasing negative densities correspond closely to the brightness of the subject.

To get a perfect positive from such a negative the paper used must also have an extended straight line response. Here precisely is where *all* photographic papers fail. While a good plate will accept satisfactorily a brightness range of 1000 : 1 the maximum for a modern paper is about 50 : 1.

The reason for this is simple. The negative material is judged by transmitted light while paper prints must, of course, be examined in reflected light. Now a pure white does not in fact exist and in even the brightest parts of the print where the emulsion has not been affected by light the paper itself absorbs a fraction of the incident light and reflects only a maximum of 80%, as can readily be demonstrated by practical measurements. At the other end of the scale the deepest shadows in the image where the paper is completely blackened do not absorb 100% of the incident light but only between 95–98%, while from 5–2% is reflected. Thus the brightness ratio between the brightest and darkest parts of the print is $\frac{80}{5} = 16 : 1$ and $\frac{80}{2} = 40 : 1$ respectively. This ratio is called the density range* of the paper.

The light reflected from the deepest shadow areas gives a type of fog which makes it difficult to discriminate between the different shadows and makes them merge together into a single tone. The correctness of this explanation can be judged for oneself by examining a paper print with deep shadow areas by transmitted light; the shadows then show quite clearly much more detail than is apparent when it is viewed by reflected light.

* The density range, properly speaking, is the logarithm of these fractions.

Photo : Sven Svenson →



This explains immediately why a disapositive reproduces the details of a negative much better than a paper print can ever do. However dense the shadow areas of a lantern slide may be it is generally possible to raise the projection brightness so that the darkest details are visible, in fact a good diapositive will exhibit the same brightness (density) range as the negative.

Despite this inherent defect in the paper the great majority of positives are made on this base. Paper prints have the great advantage of being easier to handle and can also be examined by direct viewing in the hand without the need of viewing or projection equipment. Moreover, experimental observations have shown that it is possible to distinguish 200 different tones from one another in a density range of less than 1·6 and this is quite enough for most subjects.

The importance of the paper surface

Not all papers have the same density range. Glossy papers have a brightness range of 50 : 1 or more, but matt papers rarely exceed 10 or 15 : 1. The brightness range of semi-matt papers varies from 20 to 30 : 1.

The greater the density range of a paper the larger the number of separate tones the paper can reproduce. On matt surfaced papers between 150 and 170 separate shades of grey can be distinguished, on semi-matt papers from 185 to 215, on glossy papers between 240 and 250, on lantern slides or film positives between 350 and 370 The practical conclusions to be drawn from these facts are set out in Part III.

Correct reproduction – precautions with negative

Several important precautions to be observed at the negative stage that are based on what has been said above, should be mentioned here.

We have seen that photographic paper can only reproduce a very limited brightness (density) range, and it is, therefore, useless to try and obtain on paper effects which it is incapable of yielding (the art lies in securing the impression of great range within the restricted range actually available.). Experienced photographers are well aware that in 'contre-jour' (against the light) pictures it is essential to lighten the shadows, either at the negative or positive stage, so that the brightness range is not too great to be reproduced on the print and it is for this reason likewise that studio lighting is manipulated so that the subject brightness range does not exceed the range that the paper can handle.

Why have different papers of different contrasts?

After reading what has been said about the negative, it would be reasonable to suppose that the print contrast could be controlled by variation in the time of development. This is, however, not possible, except to a very small degree. Generally speaking an increase in exposure, if compensated for by an adjustment in the development, has very little if any effect on the positive image contrast. The advantage of this is that relatively large errors in printing exposure can be compensated for by curtailing or prolonging development as may be necessary. Gevaert papers, more especially 'Ridax', have excellent latitude in this respect.

There is, if we want to control positive contrast, the choice of a number of

degrees of contrast for each type of paper. This is the reason why 'Ridax', the ideal contact paper, is supplied in six contrast grades:

0 for very hard negatives	3 for soft negatives
1 for hard negatives	4 for very soft negatives
2 for normal negatives	5 for extremely soft negatives

'Gevabrom', the universal enlarging paper, is manufactured in five contrast grades: 0, 1, 2, 3 and 4.

Portrait photography obviously has need of fewer contrast grades because, not only are the methods more precise but also because a proper control, either of the lighting or of the development (negative contrast) can be made to yield a normal negative. As a consequence a soft and a hard contrast paper are sufficient to allow for the minor variations in exposure that are inevitable.

RECONSIDERATION OF THE NEGATIVE

In dealing with the negative material we omitted to mention colour in order to simplify the description of such properties as sensitivity, exposure latitude, and correct reproduction in general. It is now time to rectify this omission.

First, let us agree that the world we see is above everything else a coloured world. All objects reflect light rays which, according to their wavelength, act on the retina to produce effects which are perceived by the brain as red, yellow, green, blue, etc. If we compare these colours one with another we see they differ not only in hue but also in brightness. Yellow is brighter than red and this in its turn is brighter than blue. Yellow-green is close in brightness to yellow and can be seen particularly well at very low intensities. This is why the yellow-green of young grass can still be distinguished at twilight when other colours have already become unrecognizable. Blue-green (the green of pine trees, for example) is on the other hand very dark.

Secondly, this multi-coloured world is reproduced by the photographic emulsion as if it were black and white and composed solely of light patches of different brightnesses from dark to light. These patches represent colours as well and now the question is whether the photographic emulsion translates the relative intensities of the different colours in the same way that the human eye does.

Colour (or chromatic) sensitivity

'Ordinary' silver bromide emulsions are to all practical intents sensitive only to the blue, violet and ultra-violet. They reproduce objects more or less as they would appear if viewed through a blue glass; the blue and violet parts of a scene retain their proper relative tones but yellow, green and red are darkened. To overcome this shortcoming, selected dyes, which absorb the rays to which the emulsion is not sensitive, are added to the emulsion (a discovery made by Vogel in 1873). These dyes (called optical or chromatic sensitizers) are adsorbed on the emulsion grains and their effect increases as the adsorption is more complete.

The emulsions so obtained are called orthochromatic if they are sensitive to

green and yellow as well as to blue and violet light, and panchromatic if they are sensitive, in addition, to red, that is to all the wavelengths (colours) of the visible sprectrum.

The precise meaning of orthochromatic (or isochromatic) ought really to be used to indicate that the plate so named as contrasted with an 'ordinary' plate renders *all* colours with the relative brightness with which they appear to the eye. Unfortunately this is very much an exaggeration, due to the understandable enthusiasm of the discoverers of dye sensitization. In fact, only the yellow and yellow-green are improved by being reproduced as lighter tones, and the plate is still predominantly sensitive to blue light.

The advantages that these new plates had became evident, however, when a yellow filter was used to suppress the superfluous blue radiation. A tone reproduction which is near enough correct could in this way be procured, provided the subject was free of oranges and reds.

When Valenta discovered in 1899 satisfactory sensitizers for the red the name orthochromatic or isochromatic

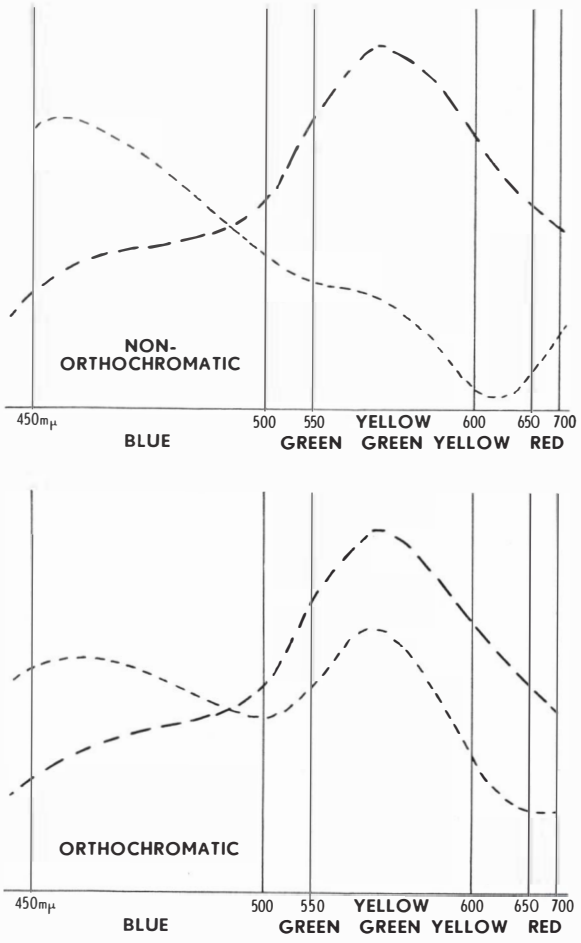
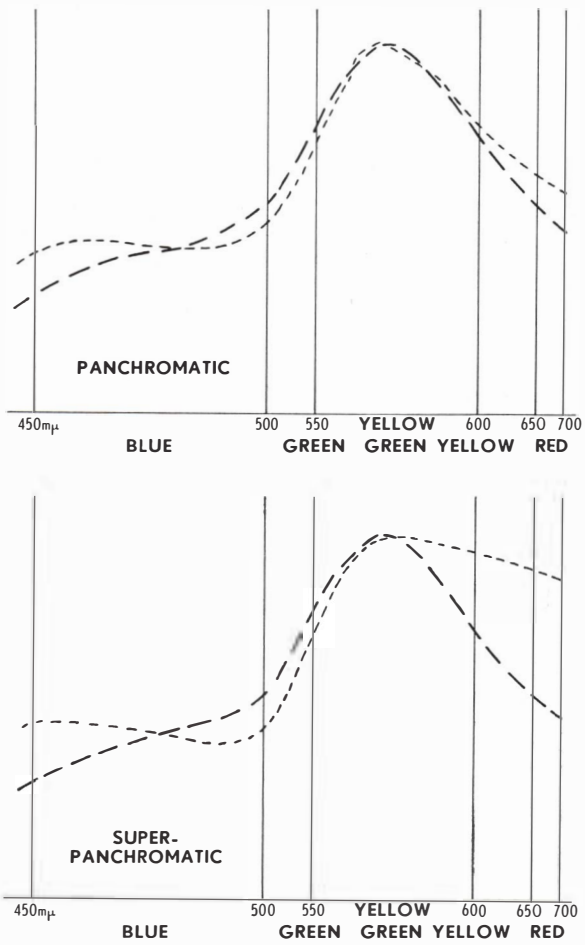


Fig. 35 The 'colour-blind' ordinary emulsion has a colour sensitivity exactly the contrary to that of the eye. The lightest tones are the blue and the darkest are the yellow.

The colour sensitivity of an orthochromatic emulsion agrees very largely with that of the eye. The blue is, however, reproduced too pale and should be darkened (yellow filter) to give the correct relative tone.

could properly have been applied to emulsions so sensitized, but by then these names had already established themselves and another name had to be found.



The colour sensitivity of a panchromatic emulsion is practically the same as that of the eye. A strictly correct tone reproduction requires a slight suppression of the blue with a yellow filter. A super-panchromatic emulsion sees the red lighter than does the eye otherwise its curve is identical with that of the panchromatic emulsion.

So the prefix '*pan*-chromatic', i.e. sensitive to all colours of the visible spectrum, was accordingly brought into use.

However, it was still not really true to say that the problem of correct tonal reproduction was solved. It was not sufficient for an emulsion merely to be sensitive to all colours but necessary also for it to be sensitive to the different colours to the same relative extent as the human eye. 'Gevapan' plates, cut films and roll films are typical of emulsions giving correct relative tonal reproduction and should therefore properly be called orthopanchromatic emulsions.

Other types of panchromatic material with enhanced red sensitivity are also used. Professional portrait photographers, in particular, who wish to reduce retouching to a minimum, make considerable use of them. With emulsions of this type skin blemishes and even wrinkles more or less disappear since they are reproduced almost as light as the normal face tones.

On the other hand emulsions over-corrected for the red (super-panchromatic) have the disadvantage that they flatten the modelling and skin texture and frequently necessitate either heavy lip make-up or retouching of the lips on the negative.

Fig. 35 shows the colour sensitivity curves for all the types of emulsions we have discussed compared to the colour sensitivity of the eye.

Grain and granularity

Basically the negative emulsion is made up of gelatine in which is dispersed a fine suspension of microscopic silver bromide crystals. Crystals that have been exposed to light are reduced by the action of the developer to form a spongy mass of metallic silver (the freed bromine combines with hydrogen from the developer to form hydro-bromic acid).

These spongy groups, called grains, are dispersed throughout the layer just as the crystals were. They clump together during development to form larger conglomerations. As a result the clear spaces between the silver particles making up the image increase in size. What is generally called 'graininess' or 'grain' when a negative is greatly enlarged, and which is the direct result of this clumping, is not due in fact to an increase in size of the individual grains themselves but to the wider spaces left between the clumps of grains. For this reason it is better always to speak of *granularity*.

How is graininess produced and how can it be avoided?

We have seen that the increase in inter grain spaces is caused by the clumping together of the individual grains. Inhibiting this clumping consequently prevents an increase in graininess. It follows that graininess is promoted by any factor which speeds up the chemical reactions which take place during development. These factors are, increase of exposure, increase of development temperature and the use of energetic developers.

On the other hand, by increasing the development time the grains are given more opportunity to clump together and this can therefore be a cause of graininess. Finally, although effective to a lesser degree, agitation during development of negative or solution or the use of a fresh bath will also tend to give graininess.

The practical precautions to be taken are, therefore, obvious. To keep the graininess as low as possible proceed as follows:

1. Give the correct exposure, i.e. regulate the exposure to give a negative of the desired contrast in the selected time of development.
2. Check the developer temperature and keep this between 68°F. and 70°F.
3. Use a low energy developer preferably a fine grain developer such as 'Refinex' or better still 'Nogranol' (see Part V for fine grain developer formulae).
4. Restrict the degree of development to give a gamma as low as can possibly give a satisfactory result. If you use 'Refinex' and 'Nogranol' or the 'Gevaert' formulae G.206 and G.224 be careful to give the development times stated. It is best, by carrying out careful practical tests, to determine beforehand the most suitable exposures to give with these developers.
5. Agitate the solution (or plate or film) gently during development.

Remarks: It cannot be too strongly emphasized that it is essential that the picture required should be made to fill the whole negative area at the taking stage, especially with miniature films, so that the whole of the negative can be enlarged. Graininess will be unavoidable, even with fine grain film and fine grain development, if small sections of miniature negatives are greatly enlarged. To show any subject on an enlarged scale it must be taken from close to (using a close-up lens) if it is itself small and reasonably flat, or if the subject is large, a long focus lens (such as a telephoto lens) should be used.



Piccadilly Circus – Photo: Harry Kerr

Anti-halation

Halation in the form of circular haloes is most troublesome when very bright and very dark areas are photographed at the same time on a single negative.

An exposure long enough to record the dark shadows obviously severely over-exposes the bright areas. This produces a light halo surrounding the highlights which completely swamps any details in the shadows which are close to the light areas. Fig. 37 will show the cause of this effect to the reader. Light rays from the objective which fall on the plate or film go through the thin layer of emulsion and are reflected back by the back surface of the glass (or film base) so exposing the sensitive layer a second time as they return. A ray S coming from a point of light strikes the sensitive layer E at a point P from which light is radiated in all directions, rays such as A and O going through the glass G. Only a very little of ray A is reflected back towards the sensitive layer. Rays B and C are, however, completely reflected, and form part of a halo round P, the complete circle of the halo being composed of all the rays so reflected all round P. In order to suppress the halo the back of the plate is coated with a coloured layer which absorbs the rays which penetrate that far. This layer is completely dissolved during processing. Such plates or films are called 'backed' films. Films for miniature photography (35 mm. mainly) are coated on a grey tinted film base to protect them from halation. This does not disappear during processing but has no deleterious effect on the image, except to increase the exposure time during enlargement, and should not be mistaken for fogging.

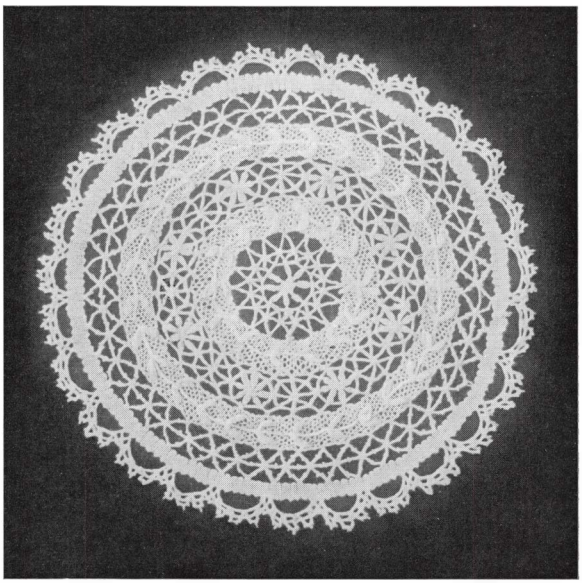


Fig. 36a Negative on unbacked plate.

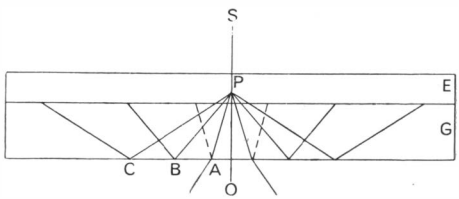


Fig. 37

An antihalo backed material shows to advantage most when there are areas of great contrast and fine details in the highlights. With ordinary unbacked material these details are more or less lost because of the diffusely bright halo borders. These reflected rays are trapped by the antihalation layer and so the fine detail is shown clearly.

Halation as we have discussed it is called reflected light halation because it is caused by the reflection of the light rays at the back face of the glass plate. Another type of halation is caused by irradiation or diffusion, that is by light spreading by scattering through the emulsion layer. The emulsion is in effect a turbid or opalescent medium which causes each point illuminated by a ray of light to behave as if it were emitting light itself. In addition each crystal of silver salt reflects and refracts the light. These 'secondary' light rays irradiate the surrounding emulsion and expose or fog it. This results in, for example, a bright point being enlarged or a bright line being thickened. This effect is, however, relatively weak and can safely be disregarded (except when using very transparent ordinary emulsions such as lantern slides) whenever definition is not predominantly important.

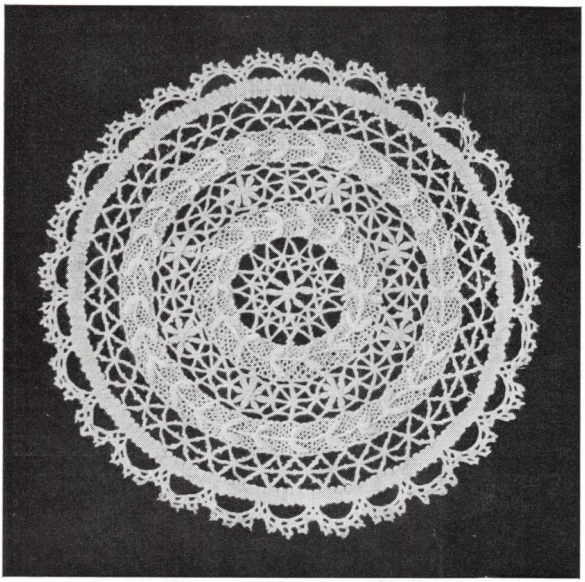


Fig. 36b Negative on anti-halo backed plate.

It is a fortunate fact that the dyes added to modern emulsions to colour sensitize them tend to reduce irradiation since they absorb radiations of precisely those colours to which they sensitize the emulsion. For example, sensitizers for the red have a blue-green colour; these dyes absorb red rays which act on the dye and are stopped at the very spot where they strike this emulsion.

When particularly high definition is needed special dyes called 'filter dyes' are added to the emulsion. This is the case with cine-duplicating and sound recording films where the slightest halation along the edges of the sound track (variable area) must be avoided. The type of 'filter dye' used depends on the colour sensitivity of the emulsion. In the two examples given above the emulsions used are unsensitized to colours other than violet and blue and a yellow filter dye is added. The dye which is finely and uniformly dispersed throughout the emulsion layer absorbs the blue and blue-violet light which falls on it and to which alone the emulsion is sensitive and so eliminates all spreading.

In other cases the same result is obtained with dyes of different colours. For orthochromatic emulsions for example a red dye is used as these emulsions are sensitive to yellow light which is not absorbed by yellow dyes whereas red dyes absorb it very well indeed.

It is worth remembering that both the amount of exposure given and the degree of development have an effect on halation, both the reflected and irradiated kind. A wise precaution is to keep these two factors down to as low a level as practicable.

Resolving power

Now as we have already said, the developed emulsion layer has silver grains in it of all different sizes, and they are distributed unevenly, as a consequence the layer is by no means homogeneous. There are as a result definite limits to the ability of the layer to reproduce in an easily recognizable form the smallest image details or in other words its power to 'resolve' these details.

To find the resolving power of an emulsion a resolving power chart is generally used. This is divided up into different areas each covered with parallel black lines separated by white spaces of the same width as the lines. On each target is given the distance between two lines in twentieths of a millimetre. Thus the figure 4 indicates that the space between two black lines is 4/20th or 1/5th of a millimetre; hence in this particular target there are five lines per millimetre.

This chart is photographed at a reduced scale – such as 1/50th – and the negative obtained is examined under a microscope, or with a powerful magnifier. The target (taking the one with the number 4 as an example) having the largest number of lines which can still be distinguished from each other – i.e. which do not merge into each other – indicates the resolving power of the emulsion. In our example the power would be $5 \times 50 = 250$ lines per millimetre.

The lines are drawn in different directions (see charts on fig. 38). In this case the resolving power is given by the target on which all the different sets of lines are clearly shown for all directions or for certain directions anyway.*

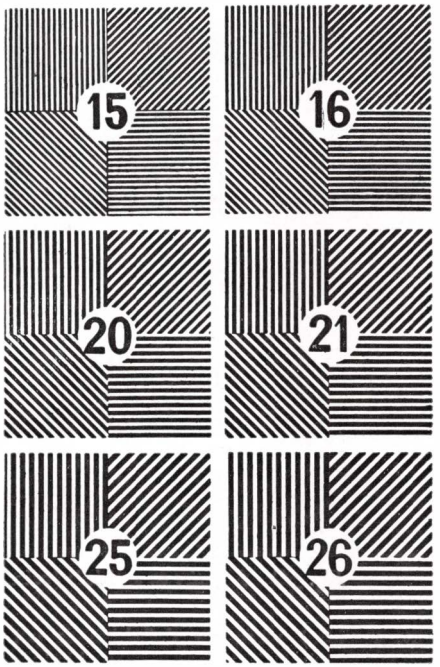


Fig. 38 Part of a Foucault Test Object.

Each target is divided into four squares in which the lines run at different angles. A photograph is taken at a much reduced scale. When is a target considered to be resolved? – at the moment no two people really agree on this point but most investigators take as a basis the target where the direction of the lines is clearly discriminated for 3 of the 4 squares.

Therefore the resolving power is the number of lines per millimetre which can be seen clearly on the negative.

* A number of commercially available charts are designed to assist in comparative tests between different emulsions.

Sand hogs in New York – Photo: Ernst Haas →

The resolving power depends on a host of factors: in the first instance on the graininess and to an even greater extent on the *irradiation*, i.e. the diffusion of image light through the emulsion layer.

As the exposure is increased from a suitably low level the resolving power also increases to a maximum value after which as the exposure is further increased the resolving power decreases. For miniature films particularly it is therefore advisable to keep the exposure as close as possible to this optimum value.

Amongst those factors influencing the resolution are: the spectral composition of the light, the developer, the resolution chart contrast (often 30 : 1) and the performance of the lens used to make the negative.

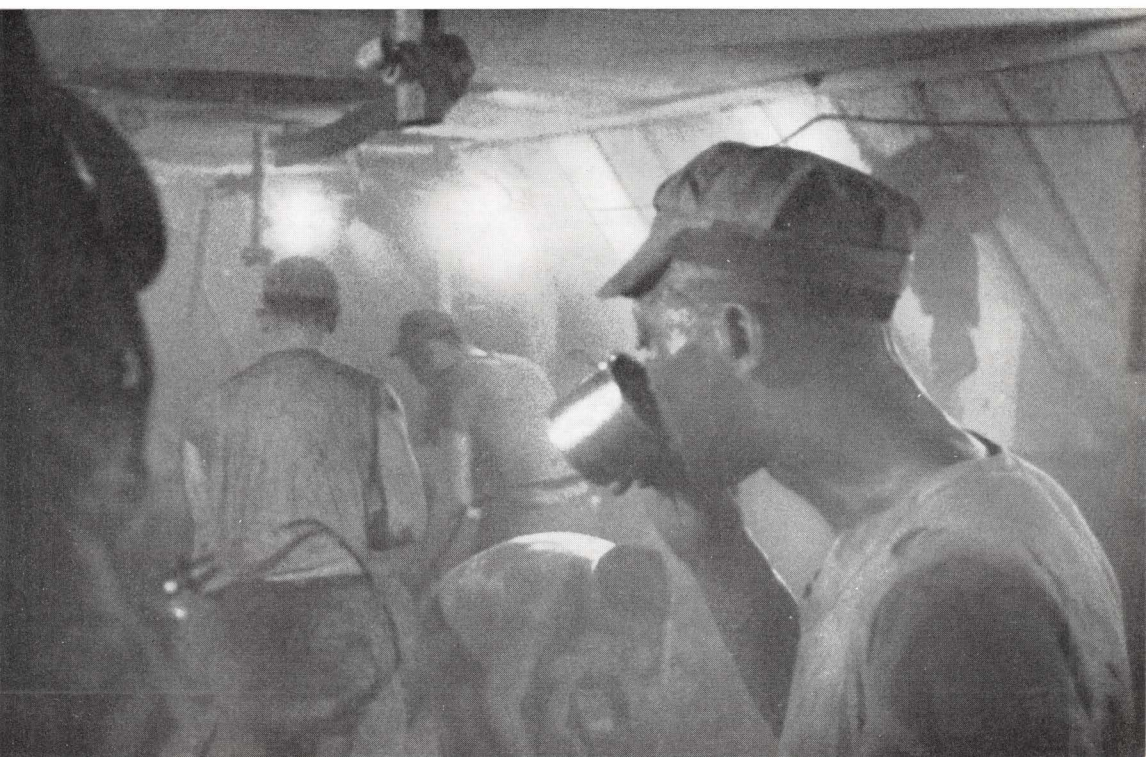
The ability of the emulsion to reproduce fine detail is predominantly influenced by graininess and the resolving power. The full resolving power is not always called into play, such as when the image resolution is judged by projection on a ground glass or on an enlarger easel. The eye under the best conditions cannot resolve more than about 10 lines/mm. It is because of this that automatic focusing often gives an improvement and why a good magnifier is useful when enlarging and a magnifying glass when focusing a ground glass image critically.

When all the factors which can influence the resolving power are so adjusted to give a high resolving power, the very best result is obtained. These conditions are not, however, normally satisfied in practice where, for instance, the development is normally adjusted to give densities which are a good deal higher (up to a density of between 1·4 and 2·0 for the densest parts) and where the contrast between the details of the subject photographed are a good deal less than the contrast of the patterns on the resolution chart.

It is better then to speak of a practical resolving power instead of the maximum or best possible resolution. We will not discuss in detail how such a practical resolving power can be determined but will simply content ourselves with tabulating the optimum values below:

★ Resolving power of Gevaert 35 mm. films

Film	*Resolving power*	
	lines/mm.	*lines/inch*
'GEVAPAN 36'	95	2,400
'GEVAPAN 33'	100	2,550
'GEVAPAN 30'	115	2,900
'GEVAPAN 27'	125	3,200



Afternoon
Teas
Luncheons
—
Dinners
EIIR

PROCESSING

In processing his sensitive material the photographer is faced with a considerable number of practical problems. First of all there are the properties of the materials he intends to use. The more he tries to avoid the subject the more he has to take account of the way in which the various constituents of his processing solutions react one with another, and how they affect the photographic emulsions.

In the preceding chapters the readers has been able to become acquainted with a number of matters of importance here, particularly those dealt with under the heading of the properties of the sensitive material.

Here we are to discuss the processing solutions and examine their components separately.

It is also important to know how best to handle chemicals in general and what other work has to be done.

PREPARATION OF SOLUTIONS

Take great care to use the correct chemicals: sodium sulphite and sodium sulphate are entirely different chemicals as are also sodium carbonate and potassium carbonate. The chemicals must as well be clean and pure. Only stupid people use chemicals of doubtful purity.

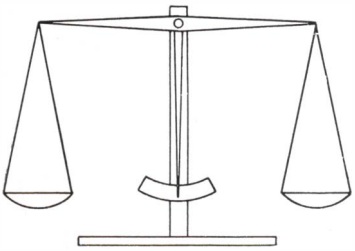


Fig. 39

Weighing dry chemicals

An ordinary pair of scales are normally adequate for weighing (fig. 39). If only small quantities are to be used a sensitive letter balance, or better, a chemical balance will be needed. Dry chemicals can be weighed on a sheet of paper, deliquescent (moisture absorbing) chemicals will need small containers. Tedious weighing of small quantities such as ½ or 1 gram can be avoided by weighing out 5 or 10 grams of a chemical at a time and making this up as a solution. This method is particularly useful with potassium bromide which is usually made up as a 10% solution (weight-volume). To make up such a solution, 10 grams of potassium bromide is weighed out and dissolved in water and then made up to 100 c.c. (*not* dissolved in 100 c.c. of water, since with a crystalline salt

<– In a London Restaurant – Photo: J. H. den Boestert

this will yield *more* than 100 c.c. of solution). 10 c.c. of this solution then contains 1 grain of potassium bromide. All chemicals are not, however, soluble to the same degree in water. The Table K, Part VI, gives the solubility of the different chemicals normally used for photography. By heating the solution quantities larger than those given can be made to dissolve, but if this is done the excess dissolved will be precipitated on cooling. It is necessary to add a preservative to the solution for certain products such as most developing agents which oxidize on exposure to air. A solution of metol* is prepared as follows: 5 grams of metol are dissolved in 250 c.c. of water. Immediately after this has dissolved completely add 2 grams of sodium sulphite (anhydrous) for each 50 c.c. of solution (i.e. 10 grams). 50 c.c. of solution then contains 1 gram of metol.

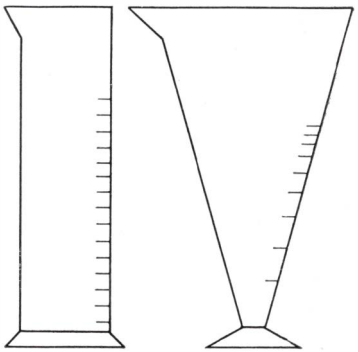


Fig. 40

Measuring out liquid chemicals

It is best to use graduated measuring cylinders or liquid measures for this work (fig. 40). An economical substitute are the graduated medicine glasses or kitchen measures used in some countries, or a bottle can be graduated for the purpose. Do this as follows: The bottle is weighed both when empty and when full of water. The difference in grams between the two weights gives the capacity of the bottle in c.c. (1 c.c. of water weighs 1 gram). The water is emptied out gradually until only 100 c.c. is left in (giving a weight difference of 100 grams). The distance between this mark and the bottom can easily be divided into ten equal parts, each division giving 10 c.c. If avoirdupois measure is required, then 1 pint of water weighs 20 oz. or $1\frac{1}{4}$ lb.

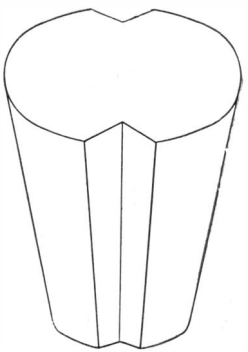


Fig. 41

It is worth mentioning that some medicine bottles (even those without side graduations) have a figure indicating their capacity moulded on the bottom, and so have many screw-topped jars; therefore, a series of bottles of different capacity can easily be got together. If it is desired to measure small quantities of liquids accurately, a tall thin graduated measuring cylinder is best, although account should be taken when measuring

* The monomethyl-para-aminophenol sulphates are placed upon the market by several manufacturers under the following trade marks: Armol, Atolo, Elon, Genol, Graphol, Metol, Monol, Photol, Pictol, Rhodol, Satrapol, Scatol, Veritol, Viterol.

of the effect of capillary action which causes the liquid surface to rise slightly where it meets the glass surface, the graduation should always be read off level with the lower portion of the surface. Some liquids are added drop by drop. For this a dropping bottle or, better, an eye dropper is needed. A dropping bottle can be made by cutting two grooves opposite each other in a cork or rubber bung as shown in fig. 41.

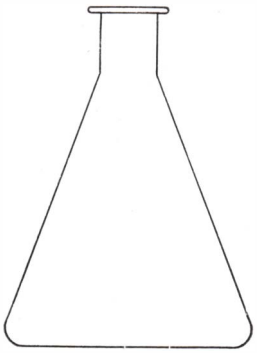


Fig. 42

Making up solutions

The way solutions should be made up depends on the nature of the substance. Some dissolve easily in water, others only with difficulty. Generally speaking, warming the solution makes the solid dissolve quicker. However, unless instructions are given to the contrary, never raise the temperature above 120°F. (45°C.) as above this temperature some chemicals, particularly developing agents, oxidize rapidly and become useless. Crystals which take a long time to dissolve can be crushed beforehand with a clean pestle and mortar, but not poisons.

Anhydrous chemicals which tend to cake in water (viz. sodium sulphite anhydrous) can be ground up with a little water in a mortar. The paste so obtained can be tipped into a graduated measure and made up to the volume required with water.

Flat-bottomed conical flasks in Pyrex or Hysil glass (see fig. 42) are strongly recommended. Their shape makes them easy to handle, and they can be heated directly on a flame to warm the contents and yet be plunged immediately into cold water without risk of breaking.

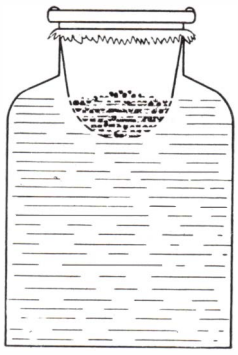


Fig. 43

A number of Pyrex glass beakers will be found extremely useful in the dark room. To mix liquids glass-stirring rods with smooth rounded ends should be provided.

It is important to dissolve chemicals in the order indicated by the formula and not to interrupt the process for too long a time or trouble will be caused. For example, in preparing a developer the metol should not be left alone in solution for long without adding the sulphite or very likely the metol will oxidize in the meantime and become useless. As a rule each chemical must be completely dissolved before adding the next. In making up developers avoid agitating the liquid unduly to prevent it taking up too much oxygen from the air.

To dissolve hypo and potassium metabisulphite, the chemicals can be placed in a small bag which is hung so that it dips into the top of the water. For this a clean piece of linen or muslin can be used (fig. 43) in the centre of which the

chemicals are placed. This is lowered through the top of the jar until it is just covered and the edge of the cloth then fastened over the neck of the jar. The salts then dissolve very rapidly, the saturated hypo or metabisulphite solution falls to the bottom of the container while the cloth bag holding the undissolved salt remains immersed in the least saturated portion of the liquid.

★ Percentage solutions

To make up, for example, a 10% aqueous solution a suitable quantity of the dry salt is dissolved in a small quantity of water and this is diluted further until it is 10 times the weight of the dry substances.

Thus to prepare 500 c.c. of a 10% potassium bromide solution $\frac{500}{10} = 50$ grams of potassium bromide are weighed out, dissolved in water and made up to 500 c.c.

Suppose we wish to obtain a percentage solution of lower concentration using a more concentrated solution. To determine quickly how much water should be added make use of a diagram of the type shown below which is in common use for calculating the percentage value resulting from the mixing of two solutions of differing percentage concentrations. The diagram is like this:

On the left are put the percentages of the solutions available, on top the concentrated solution (95%) below water (0%). In the middle is the percentage required (25%). This is subtracted from the original concentration (95−25=70) and the result is put below on the right, above this is placed the result of deducting the water from the solution concentration required (25−0=25). The result required is, therefore, as follows: if 25 parts of the concentrated 95% solution are mixed with 70 parts of water a 25% solution will be obtained.

95		25
	25	
0		70

Warming solutions

To heat solutions chemists use a Bunsen burner with an air adjustment, fig. 44. This method of heating with an iron tripod and a piece of metal gauze or asbestos to support the flasks and beakers is easy and quick to use. For these reasons the increased use of Bunsen burners in photographic laboratories is strongly recommended.

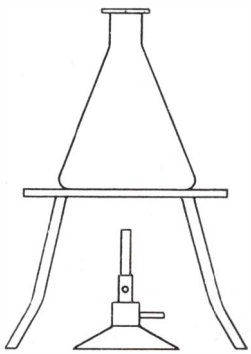


Fig. 44

In compounding developers the solvent (water) should be warmed to assist in dissolving the chemicals. Too high a temperature, however, will tend to oxidize the developing agent and the sulphite. 110°–120°F. (40°–45°C.) should not as a rule be exceeded. When making up a hardening fixing bath it is better to add to the fixer a solution of the hardening agent which is itself at normal temperature or otherwise the fixing salt may decompose. This will produce free sulphur and this may lead to spots on the emulsions.

To heat up baths during development, a small immersion heater is advised. The heater should not be touched with wet hands (electric shocks!) and the heater should be cleaned scrupulously after use.

Cooling

Liquids as we have already said are generally heated to assist in dissolving the chemicals. Before being used the solutions have to be brought back again to the working temperature. To do this the flasks can be put under a cold tap having covered the neck over with a beaker or glass.

If bulk solutions have to be cooled it pays to install cooling coils passing iced water or refrigerant in the place where the storage jars are kept, or to pass the solutions through cooling coils, or to place cooling coils in the storage jars.

Filtering water and solutions

To obtain the best results in photography it is essential that solutions should be made up with pure water. Distilled water is, therefore, often called for, but since this is not always available it is necessary to have a means of filtering ordinary tap or pump water.

Impurities are of various kinds. Among the most frequent are suspended organic and inorganic matter, soluble and insoluble salts of calcium and magnesium and sometimes also sulphides. Suspended particles can settle on the emulsion and give spots. Insoluble salts of calcium and magnesium combine with the sulphites and carbonates of the processing solutions and give rise to troubles no less serious than those caused by suspended matter.

Iron can cause spots. Sulphur which is present in water as sulphate has a great affinity for silver (forming Ag_2S) and this also is a source of spots.

Most of these impurities can be got rid of by boiling the water, allowing it to stand, and pouring off the clear liquid. The suspended particles coagulate and settle, likewise the insoluble salts and iron particles, while hydrogen sulphide (sulphuretted hydrogen) evaporates. In addition the dissolved air is driven off, which is of advantage when making up developers.

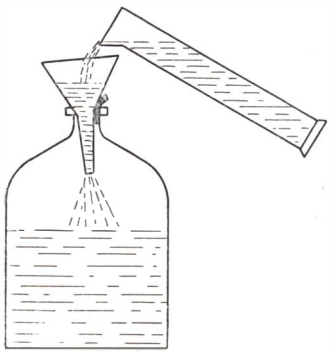


Fig. 45

When the water has settled down and become clear it is poured off carefully (decanted) so that the sludge is left at the bottom of the container.

Those who wish to perform accurate and exacting work should filter the water when it has been clarified in this way. A clean piece of linen will generally be found suitable for this purpose. A plug of cotton wool can also be used in the funnel. If iron or rust particles cause trouble in washing a linen bag can be tied over the wash tap. Soluble salts of calcium and magnesium cannot be got rid of by boiling. If they prove to be a nuisance the water can be purified by adding sodium carbonate (see Part V).

The solutions themselves as well as the water must be free from impurities. The best way is to filter them. To filter developers and other easily oxidized

solutions filter paper is too slow and should not be used. Instead use a piece of linen, placed over the funnel or the neck of the container. Do not forget to wash or replace the linen each time. Allow the air to escape from the bottle during filtration by wedging a folded piece of cardboard between the funnel and the side of the bottle (see fig. 45), or use a ribbed or square funnel.

Trays (dishes) and tanks

It is not advisable to use tanks and trays of unprotected metal because metals react with some photographic chemicals to form substances which can ruin negatives and prints by causing fog, spots and other defects. Stainless steel trays and tanks are, however, an exception and give every satisfaction. Hard rubber trays and tanks are also very satisfactory, but they are inclined to perish and grow brittle and eventually to become porous. Tanks and trays constructed of plastic do not suffer from this defect.

Trays of enamelled steel are much used, but they have the disadvantage of losing their enamel in places after being in use some while, which leaves the steel bare and can cause trouble especially when using potassium ferricyanide for reduction. The best trays to use are porcelain or glass: they are unaffected by all solutions used in photography and are easily cleaned. Those made of compressed fibre card, wood or hardboard and protected by a suitable varnish are suitable for processing enlargements: trays made of xylonite or other plastics are very suitable in small sizes and in clear or opal Perspex in larger sizes, but stainless steel has generally replaced other materials for professional continuous use in large sizes. Porcelain trays, unless of the very best quality, eventually crack and craze and enamelled steel has to be of heavy gauge to prevent crackle. Stainless steel, although initially expensive, proves the most economical in the long run.

White trays are particularly recommended for processing negatives since they assist in the inspection of negatives during development.

Always reserve the same tray for the same kind of work. Never develop in a tray that has been used for fixer, the smallest traces of fixer in the developer will give trouble.

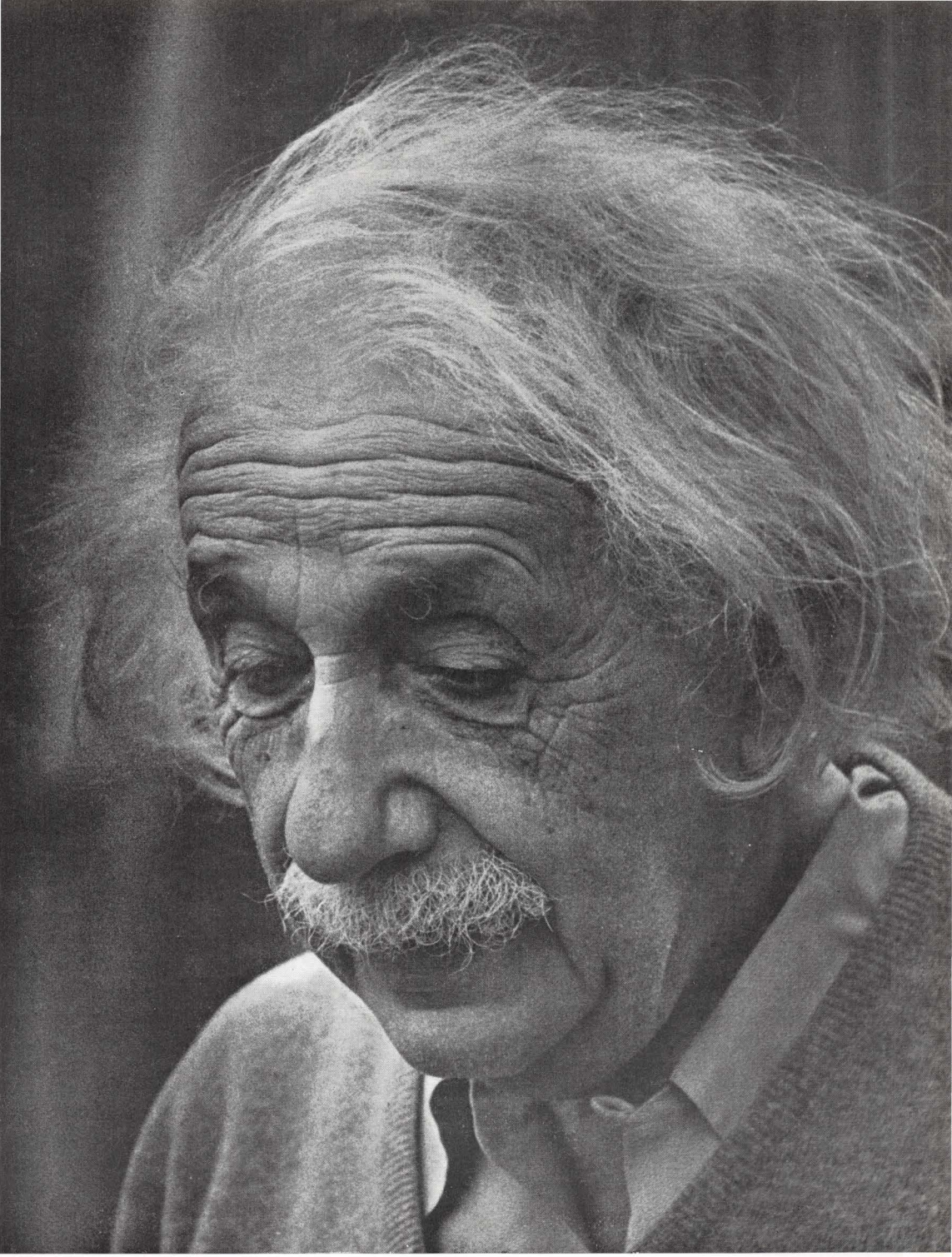
For making up solutions use conical glass flasks or glass bottles or earthenware crocks or tanks. Here, too, it is best to keep special containers for the separate solutions.

Storage of chemicals and solutions

In a laboratory order and method save much time and effort and make work much more pleasant.

Most chemicals are kept in bottles: dry materials in wide necked jars with glass stoppers or corks and liquids in narrow necked bottles preferably corked. Bakelite screw-topped jars have recently become almost universally used. Bakelite is immune to attack by fumes from strong acids or alkalis. The screw cap does not stick as easily as does a glass stopper and in addition this type of jar is relatively cheap; they need, however, a resilient pad inside the cap to make them airtight.

Einstein – Photo: Ernst Haas →



As a general rule dry chemicals keep in good condition longer than solutions.

Hygroscopic substances (i.e. those which absorb water from the air) such as soda, potash, ammonium bromide, ferric, calcium and gold chloride, potassium citrate, ammonium thiocyanate, etc., should be kept in tightly corked bottles; if they are left in an open jar or a paper container they soon become deliquescent.

Some crystalline substances rapidly lose their water of crystallization on exposure to air and these too must be kept in well stopped bottles. This applies to sodium carbonate, sodium sulphite and oxalic acid.

Easily oxidized solutions, particularly developers, should be stored in full bottles so that as little oxygen from the air as possible is in contact with the liquid. If large quantities are normally used it pays to split them up into several smaller containers. When only a part of a bottle is used a few drops of ether can be dropped on to the remaining solution to expel air from the bottle.

In many cases the various constituents are kept separately and are mixed immediately before use. Developers for instance can be kept separately with the developing agent and preservative in one solution and all the other constituents in a second solution. This is particularly advisable with high energy developers, such as those containing caustic soda used for process work, and the para-formaldehyde types.

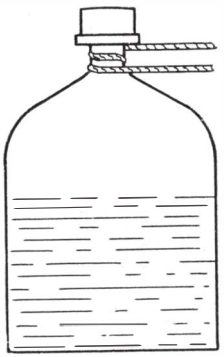


Fig. 46

For easy identification of solutions stick a label on each bottle indicating the contents by means of one or two large letters or figures, e.g. for 'Ridax' developer the capital letter R. With a solution which is used only occasionally the formula can be written on the label and also the date when it was made up. It is advisable to use special poison bottles for dangerous chemicals and to keep these safely under lock and key. Labels can be protected by coating with a cellulose varnish (see Part V).

Chemicals that are sensitive to the action of light, such as silver nitrate, gold chloride, pinacryptol green, pinacryptol yellow, potassium cyanide, oxalic acid, as well as organic chemicals like developing agents are best stored in dark yellow or brown bottles, preferably away from the light. *Ammonia* (ammonium hydroxide), *sodium sulphide*, and *formalin* (formaldehyde) should be stored in a separate place. Sensitive material stocks should be carefully stored in a place well away from all chemicals and as far as possible from those three just mentioned which are especially inimical.

If a glass stopper gets stuck, warming the neck of the bottle will loosen it, as the neck will expand and free the stopper. A practical tip is to wind a piece of string round the neck and to pull this to and fro rapidly (see fig. 46). Often enough a few sharp taps with something hard will be sufficient to free it. If the bottle has liquid in it tip it upside down so that the liquid can seep down past the stopper. Keep powdered and crystalline chemicals in wide necked bottles.

DEVELOPMENT

★ Darkroom lighting – desensitization

Development can only be carried out in non-actinic light, viz. light which has little or no effect on the emulsion. Complete darkness is necessary in some cases. Instruction leaflets for Gevaert products always state the correct safe light to be used for each type of material. Panchromatic plates and films cannot be handled in red light unless they have been previously desensitized to the red. To do this the plate or film should be immersed for *two minutes* (in complete darkness, or several feet away from a very dim green safe light) in a bath made up as follows:

Stock solution:	Warm water	1000 cc. (1 litre)
	Pinacryptol green . .	2 grams

This solution keeps a long time in the dark. For use it is diluted as follows:

	Water	1000 cc.
	Stock solution	50 cc. (i.e. 1 in 40)

★ Development

The emulsion appears unchanged after exposure (except for P.O.P. papers for daylight printing, in which the image appears during the exposure). The image is therefore present in a *latent* condition although at that time invisible.

Development makes the latent image visible by the action of certain chemicals on the emulsion. These developing agents reduce the silver bromide affected by light during the exposure, leaving intact the bromide which has not been exposed. The reduction of the *exposed* silver halide is brought about by the decomposition of the silver bromide, chloride and iodide into silver and bromine, chlorine and iodine. The silver remains in the gelatine as a black deposit while the free bromine, iodine and chlorine pass into solution where they react with other chemicals. A developer has to fulfil many different general requirements. The principal property it must have is the ability to reduce only the exposed silver salt leaving the unexposed silver salt untouched, otherwise it will cause fog. As well as this it must be efficient at normal temperatures, consistent, have a good working life and be odourless. In addition a developer has to satisfy a number of particular requirements according to the use to which it is to be put. Sometimes the most important of these are the ability to give high contrast and speed, sometimes it must give fine grain, or be suitable for use at high temperatures. For these reasons different agents are compounded in many ways so that in each case the final solution gives the result intended.

Developer composition

★ Developing agents

The most used ones are: metol, hydroquinone, glycin, pyro, pyrocatechin, amidol, paramidophenol and paraphenylene-diamine. Each one of these chemicals has special properties.

Metol is a very energetic developing agent, it shows up fine details in the deepest shadows and is particularly useful in developing over-exposed negatives as the image only increases in density

slowly. Used on its own as a developing agent in a developer metol gives very soft negatives, clean and well detailed. As a rule metol is used in conjunction with hydroquinone. To improve its keeping qualities in solution it is advisable to dissolve a small quantity of sulphite in the water before adding metol.

Hydroquinone has only a weak developing action for low levels of exposure. On the other hand it gives the greatest contrast of all the developing agents. It is used on its own with caustic alkalis like caustic soda when a contrasty black and white result is desired, e.g. for line work in the graphic arts. The heaviest deposits of silver are produced when caustic alkalis are used as accelerators.

Hydroquinone is very sensitive to temperature variations. At 60°F. (15°C.) it has practically no action. Solutions also go brown quickly due to oxidation.

Glycin gives perfectly detailed negatives not thin or clogged. In addition it has less tendency to give fog than either metol or hydroquinone. It keeps well in weak solutions and is therefore always the best to use for prolonged or slow development. This agent is universally employed in developers to give warm toned positives.

Pyro (Pyrogallol) gives fog-free negatives full of detail. With only a little alkali they are soft, with a lot of alkali, hard. The colour of the negative varies from transparent brown to a blue black. The more sulphite a pyro developer contains the more the tone inclines to blue black. The developing action of this formula is to a large extent controllable by the addition of potassium-bromide.

Pyro is little used on the Continent, but very much so in tropical countries, because of its tanning properties. If the development is prolonged or the developer solution is contaminated with fixer, pyro readily gives dichroic fog. A disadvantage of its solutions is that it turns the fingers brown. As usually made up this developer stains the image strongly. This stain is proportional to the silver density and has the effect of intensifying the negative and enhancing its printing contrast.

Pyrocatechin gives clean well-detailed negatives. Increase of alkalinity has a great effect in raising the activity of this developer. Pyrocatechin developers do not keep well in dilute solution and should be kept as two separate stock solutions. Pyrocatechin is not very much affected by variations in temperature.

Amidol will work when used with sodium sulphite alone and gives the best results when used in this way. A fresh bath should always be used as it oxidizes rapidly and this soon causes fogging. It stains the fingers heavily (remove stains and spots with sodium hypochlorite – Milton or weak Parazone or Domestos). 'Amidol' cannot be used conveniently for long development times. It gives prints with a rich deep black when used as a paper developer.

Phenidone used alone is a sodium carbonate-sulphite solution, gives a very fast but extremely soft working developer. Phenidone is highly active in formulae with hydroquinone and retains its activity well. It is moderately soluble in hot water and slightly in cold water.

Paramidophenol with a caustic alkali as accelerator has the advantage of being able to be kept at a high concentration. It does not readily give chemical fog even at elevated temperatures and for this reason is useful in the tropics. A large number of proprietary concentrated developers are marketed containing this agent, e.g. Azol, Rodinol, Kodinol and many others.

Paraphenylene-diamine gives a rapid developer when used with caustic alkalis. Without alkali or in a weakly alkaline solution (e.g. borax), a fine grain developer results.

To speed up initiation of development with fine grain developers containing sulphite which are very slow acting a small amount of metol or glycin is often added. This naturally increases the graininess somewhat by an extent which corresponds to the amount by which the development is accelerated.

★ Accelerators

Metol is the only developing agent which will give an image when used without any other chemical. The image is, of course, very weak and of no practical use.

The reduction of the silver salt has, therefore, to be set in motion by the addi-

Photo: Fulvio Roiter →



tion of some other chemical which energizes and accelerates this reduction. The chemical normally used for this is a caustic alkali or a carbonate.

Sometimes metol and amidol are used without any accelerator with only a preservative (sodium sulphite) added. This is weakly alkaline, but sufficiently so to give satisfactory fine grain development.

The accelerators that are most frequently used are: free alkalis such as caustic soda and caustic potash (sodium and potassium hydroxide or hydrate) and alkaline salts of weak acids which, on hydrolysis, react like alkalis, particularly potassium carbonate, sodium carbonate, and borax and sodium metaborate.

Free alkalis are the most active and are consequently used with the slowest developing agents (such as hydroquinone) since these would otherwise need quantities of sodium or potassium carbonate too large to be conveniently dissolved in the volume of solution required.

In fact the developing agent is only activated by the caustic alkali. This is because when an alkali carbonate dissolves in water a small amount is decomposed into caustic alkali and bicarbonate (e.g. $Na_2CO_3+H_2O \rightarrow NaOH+NaHCO_3$).

During development this conversion by *hydrolysis* goes on continuously so that in effect the carbonate acts as a reservoir of caustic alkali, only a little of which, however, can be active at any one time.

The most soluble caustic alkali is caustic potash as will be seen from the following table:
100 parts of water (at 60°F.) will dissolve:

200 parts caustic potash	60 parts caustic soda	90 parts potassium carbonate
63 parts Sodium carbonate (cryst.)		16 parts Sodium carbonate (anhydr.)

A strongly alkaline solution will cause the gelatine layer to swell, thus allowing the developer to penetrate more easily so that the density of the negatives is increased. The amount of alkali should not, however, exceed a certain limit, otherwise the gelatine will swell too much and fogging will result from the reduction of silver bromide which has not been exposed.

Potassium carbonate to be used as an accelerator must be quite pure.

Borax is only feebly alkaline and is used as an accelerator in fine grain developers.

★ Preservatives

A developing agent with alkali on its own will rapidly oxidize, turn brown and lose its developing power. Instead of developing the latent image it will yield only a general fog. To avoid oxidation (viz. the combination of the developing agent with the oxygen of the air) a preservative substance is added to the solution. Those most frequently used are *sodium sulphite* and *potassium metabisulphite*.

Sodium sulphite plays a double role: not only does it prevent the developer becoming rapidly oxidized by combining itself with atmospheric oxygen (forming sodium sulphate) but in addition it helps to activate the reduction and help to blacken the negative particularly affecting the colour of the silver deposit. It gives rise to a silver deposit which is blue black or an intense black.

It is unwise to raise the concentration of sulphite beyond the useful limit. If the developer is very rich in sulphite then some of the silver bromide of the sensitive layer is dissolved especially with long development times, and this causes other side reactions to occur in the solution which result in a coloured deposit of finely divided silver (colloidal silver) which is deposited on the emulsion surface as a yellow or dichroic fog. Dichroic fog assumes different colours by reflected and transmitted light and the angle of view rather like shot silk.

Potassium metabisulphite keeps better in solution than does sulphite.

One hundred grams of sodium sulphite can be replaced by 44 grams of potassium metabisulphite. However, since the metabisulphite dissolves to give a rather strong acid reaction the development will be considerably retarded. This can be compensated for by increasing the amount of alkali used (also in cases where sodium sulphite and potassium metabisulphite are used together). For each 10 grams of metabisulphite used add either 12 grams of potassium carbonate of 9·5 grams of anhydrous sodium carbonate (or 5 grams of caustic potash, or 3·6 grams of caustic soda). These figures of course only apply to pure dry chemicals.

★ Restrainer

By preventing the developer from reacting too vigorously and so reducing silver salts which have not been exposed, these chemicals help to prevent the formation of fog and assist in giving clear bright negatives. The most commonly used retarder is potassium bromide. Retarders can only be used in relatively small quantities or they will slow down the action of the developer unduly and in the case of papers, give a most unpleasant greenish tone to the image.

★ pH value

In dealing with accelerators both weakly and strongly alkaline substances were mentioned. In making up solutions substances with an alkaline reaction may be mixed with other substances having an acid reaction. How can the degree of acidity or alkalinity of the resulting solution be determined?

Litmus papers, which are well known, will give a rough indication: blue paper goes red in an acid bath and red paper turns blue in alkaline solution; if the liquid changes neither a blue nor a red paper it can be considered neutral; this is what happens for instance with distilled water.

Litmus and similar papers cannot, however, show the *degree* of alkalinity or acidity of the solution. This is where pH comes in. It is not necessary to know the precise definition of pH to be able to understand the numerical values in which it is expressed; it is sufficient to understand the figures that follow: pure water is neutral and has a pH of 7·0; values below 7·0 indicate acid solutions and values above 7·0 alkaline. Strong acids have pH values between 0 and 2·0 strong alkalis between 12·0 and 14·0.*

In the table below are shown as examples the pH values for some of the more important Gevaert formulae:

Solution	*pH*	*Solution*	*pH*	*Solution*	*pH*	*Solution*	*pH*
Developers		*Fine Grain Developers*		*Fixing Bath*		*Stop bath and hardeners*	
Metinol	10·5	Nogranol	8·7	G.301	4·4	G.351	3·6
		Refinex	9·2			G.352	4·0
G.251	10·6	G.206	9·5				
		G.224	8·9				

It will be seen from this table that:

1. Developers are *alkaline*, whereas stop baths, fixers and hardening baths are *acid*.
2. Fine grain developers are *less* alkaline than other developing solutions. The lowest pH in this

*pH is the logarithm of the hydrogen ion concentration with negative sign (i.e. the log. of the reciprocal). A solution of pH 3·0 is, therefore, ten times more acid than one of pH 4·0. A solution whose pH is 9·0 is ten times more alkaline than a solution of pH=8·0.

classification is '*Nogranol*' which agrees perfectly with the statements made above about fine grain development.

★ Keeping properties of developers

All developers oxidize in contact with the air and lose thereby their activity. In addition the bromide ions liberated by the reduction of the silver bromide react with certain salts in the developing solution, and this also reduces the efficiency of the developer. As a consequence the developer acts more slowly and turns first yellow then brown. When it becomes a dark brown it should be renewed.

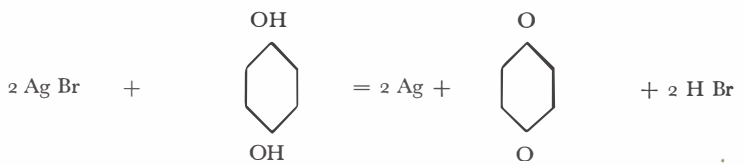
Some photographers do not discard all their developer but instead they replace a part of the exhausted solution with a fresh developer prepared without potassium bromide. This method, which is only practicable for negative development, has the advantage that the developer activity can be maintained at a more or less constant level thus allowing development under constant conditions. This is of great importance especially for tank development or for long development times. In this case the development is kept reasonably constant because the extreme variation between a fresh developing solution and one that is practically exhausted is thereby eliminated.

Most formulae which are in large scale use for photo finishing, cine, and professional use are replenished on a replacement basis, the solution which is carried over in the developed emulsion layers being replaced by an equal volume of a specially compounded replenisher solution which, besides having less bromide, is so designed to keep the constitution of the developer as constant as possible. In this way large quantities of sensitive material can be processed without changing the bulk of solution over long periods. Usually a quantity of replenisher at least equal to the original volume of developer can be added before the total accumulation of organic matter and developer products render the bath unsatisfactory. Such baths are frequently 'buffered' to maintain a constant pH.

★ Chemical reactions in development

The chemical reactions that take place during development can be represented in a schematic form as follows:

Development: AgBr exposed + reducer = Ag + oxidized reducer + hydrobromic acid.



Exposed silver bromide + hydroquinone = silver image + quinone + hydrobromic acid.

With AgCl the same reaction occurs.

Types of developers

Developers can be divided into types according to the method of use for which they are intended, those for tray development and those for slower tank development.

In Part V the reader will find a number of Gevaert formulae suitable for plates, films and papers. The various needs and methods adopted by both professional and advanced amateurs have been taken into account in compounding these formulae. Some solutions should have a gentle action, others need to be energetic. Some photographers for one reason or another will prefer for example glycin or pyrogallol.

As far as papers are concerned there are several additional factors which must be taken into account, and not only the tonal gradation but also the image colour must be considered. As a consequence additional paper developer formulae are included.

★ Fine grain developers

The formulary also gives those *fine grain developers* which have in recent years become extremely popular. In what respect do they differ from other developers? Principally in that they are less alkaline. Instead of the usual alkali accelerators, salts with a feeble alkaline reaction are used, such as borax. In some cases sodium sulphite which is only weakly alkaline replaces the alkali. Weak alkalis have the advantage both of causing the gelatine to swell only slightly and of causing less clumping of the silver grains.

In addition a fine grain developer usually contains a substance which exerts a slight solvent action on silver bromide which is intended to assist in promoting finer grain. Sodium sulphite is an example – it is generally found in fine grain developers in larger amounts than are required for merely preservative action. Sometimes formulae for fine grain developers call for other silver bromide solvents such as ammonium chloride, potassium thiocyanate and even sodium thiosulphate (hypo).

After the solution has been in use for some time, dissolved silver turns the solution cloudy, apart from this, it has no undesirable effect.

'Refinex' and G.206 are excellent formulae for fine grain developers, 'Nogranol' and G.224 for ultra fine grain.

Care should be taken in using these solutions, that the temperature is kept as close as possible to 68°F. (20°C.). Any rise in temperature promotes clumping of the silver grains. At other temperatures different times of development are needed. Tables are given for most developers giving the necessary instructions on this point.

★ Compensating developers

By a compensating developer is meant a developer having the ability to compensate for large brightness differences between the shadows and the highlights by holding back the development of the latter. This effect can be procured by

cutting down the amount of alkali and/or increasing the amount of potassium bromide. Such a developer acts primarily at the surface and penetrates only slowly into the interior of the emulsion layer so that for subjects of extreme contrast the negative can be kept in the developer until the shadow details come up without having to worry about clogging up the highlights.

The full benefit of compensating developers is particularly apparent in developing against-the-light shots and negatives of interior scenes with brightly lit windows. In addition it should be noted that halation is much reduced by using compensating developers.

After what has been said above about fine grain developers it will be appreciated that because of the lowered alkalinity they must also be considered to be compensating developers.

We conclude with a word about development in the tropics. The chief difficulty met with in hot countries is the swelling of the gelatine. To keep the swelling down to the normal amount, acid amidol developer can be used or 10% of sodium *sulphate* (cryst.) can be added to an ordinary developer. For the best results use Gevaert formulae G.222A or G.223 and fix in a hardening fixer bath, or use a separate hardener between development and fixation.

The importance of temperature

As we have already seen, the negative contrast varies with the degree of development, and this gives a means whereby we can control the final result.

But this is on one condition only: that the temperature is kept constant. Development proceeds more rapidly in a warmer solution. With papers the developer temperature also affects the image colour. This is not necessarily of itself a nuisance. Provided we know exactly what we want it is easy enough to raise the developer temperature as required to procure any particular effect. For instance, press photographers who are frequently forced to resort to very brief exposures (under-exposed negatives) can force up ghost details by warming up the developer. But, in general, these methods should be regarded as exceptional. For normal working to obtain constant results the recommended temperature should be adhered to. This is particularly the case with prolonged and tank development in which it is rarely practicable to control the development while it is in progress. However, it is usually difficult to prevent the solutions rising to some extent above the recommended temperature during hot spells. The time of development must then be reduced. Similarly it must be increased when the developer gets too cold.

Development above 77°F. (25°C.) and below 57°F. (14°C). is not recommended. Temperatures below 57°F. are too low for formulae containing hydroquinone, since this becomes practically inactive below 59°F. (15°C.).

All developers are affected by changes of temperature in the same way but not all to the same degree. For example, heat increases the rate of development and cold slows it down, but some developers are more strongly affected than others. Metol, for instance, is very little affected by variations in the tempera-

Photo: Frank Philippi →



ture, while hydroquinone is strongly influenced by temperature and is practically inactive below 59°F. (15°C.). On the other hand at high temperatures hydroquinone is more active than metol.

The temperature does not only affect the developer itself. Raising the temperature causes the gelatine to swell and this assists the developer to penetrate the emulsion layer and so speeds up development. Cooling prevents the gelatine from swelling so much and as a consequence the process of development is retarded. Excessive swelling of the gelatine causes the sensitive layer to be undesirably fragile and slows up drying. Over-swollen gelatine also very easily melts under the action of heat. To overcome this disadvantage, the gelatine should be hardened which has the effect of raising its melting point. This hardening can either be incorporated during the process of manufacture, this being so in the case of Gevaert papers which are to be glazed or dried by heat, or by the user himself (see Gevaert formulae G.354 and G.356 for hardening plates, films and papers).

There are other faults which can be caused by too high a temperature, the emulsion coming away from the edges of the support (frilling), general fog, yellow fog, and dichroic fog. Finally, it should be noted that any considerable variations between successive processing solutions will have unpleasant consequences.

Transferring plates or films from a cold into a hot solution causes the gelatine to swell suddenly just as a cold solution following a warm one will cause a sudden contraction. Such rapid changes in the volume of the gelatine layer can give rise to various undesirable effects, for instance 'reticulation' which has the appearance of a very fine pattern of lines or cracks. This defect can be attributed to the sudden swelling or contraction of the gelatine and can also be caused by transferring the sensitive material from a strongly alkaline to a strongly acid bath and vice versa.

These troubles usually occur while going from developer to fixer and from fixer to washing water, especially when there is a temperature difference of more than 10°F. (5°C.) between the baths. It is worth recalling that in dissolving hypo and fixing salts absorb heat and therefore cool the solution. It is best to dissolve the crystals some good while beforehand in warm or tepid water and then to allow the solution to reach the temperature of the surroundings.

In summer time if the water is too warm it is as well to add to the first wash water a small quantity of cooking salt to obviate excessive swelling of the gelatine and the reticulation that may result.

Serious variations in temperature can also cause the emulsion to come right away from the support or cause blisters.

Methods of development

★ Tray, often called 'dish', development

This method has the advantage that the appearance of the image can be watched and the development stopped as desired.

A negative is considered to have been *correctly exposed* if during development

the highlights appear first followed progressively by the intermediate tones and finally by the shadows. If the exposure is correct the deep shadows remain quite clear, only showing a very light grey final density, the rebates should be quite clear or only slightly fogged on very fast materials. Moreover, the negative ought to be completely developed by the time recommended for the developer formula. If the highlights come up rapidly after very short immersion and almost immediately after them the intermediate tones then the negative must have been over-exposed. When development is finished it will be very difficult to make out anything by transmitted light and the negative will be almost completely black. If the opposite occurs and the highlights come up slowly and the intermediate tones and shadows take a long time then it is obviously under-exposed.

As a general rule a negative can be considered completely developed when the highlight and intermediate tone details (i.e. the dark parts of the negative) can be seen quite clearly through the back of the negative when this is examined by the reflected light from the darkroom safelight. The highlights are then almost opaque. The development can also be stopped as soon as the deepest shadows (the clear parts of the negative) just begin to take on a light grey density. The choice of one or other of these two methods depends on personal preference and the use to which the negative is to be put. It is, of course, possible to use both criteria simultaneously. In this as in all things, practical experience will decide.

The belief that graininess increased with gamma and density and that in some cases improved tonal rendition could be achieved by using the 'toe' of the curve led to a tremendous vogue for the 'thin' negative, especially among miniature workers. For professional use in larger sizes or where a really fine-grained material can be used on subjects of normal brightness contrasts slightly denser negatives make for much easier working since the effects of dust, dirty scratches and retouching are much less apparent on the final result.

Set about development in the following way:

Place the exposed plate or film in the tray emulsion side up, then empty over the developer *in one go*. The negative can also be plunged into the developer in such a way that the whole of the emulsion layer is covered by developer at the same time. Keep the tray moving gently during the whole period of development.

If the developer is left undisturbed the developing action will be held back in certain areas due to the local action of the bromide salts, which are liberated by the action of the development, only diffusing slowly away and so exerting an undesirable action on the emulsion layer. This gives rise to uneven 'patchy' development. The rocking of the tray has the effect of replacing the over-bromided developer by fresh solution.

Contrasty negatives (e.g. against-the-light and interiors) should be developed in developer diluted with 1 or 1½ parts of water. By doing this the highlights blacken more slowly and the intermediate tones and shadows have time to develop up. If the negatives are under-exposed then the developer may with advantage be warmed to 70°–77°F. (20°–25°C.) and a freshly prepared solution

should for preference be used. For an over-exposed negative several drops of 10% potassium bromide solution can be added to the developer.

In developing plates and films by inspection be careful not to bring them too close or particularly to keep them exposed too long to the light from the darkroom safelight lamp or fog will certainly be caused, as the radiation from the safelight is never entirely inactive.

Lastly, it is absolutely essential to insist on cleanliness. The table or bench on which the trays are used should be free from dust and from spilt chemicals, both solids and liquids, which will dry and powder. After dipping fingers in solutions care should be taken to rinse them in water and to wipe them dry. If this precaution is neglected oxidized developer will be put back into the tray and the fingers will soon be stained brown. A more serious defect will be the introduction of stop bath or hypo into the developer which will ruin its activity or cause dichroic fog.

The method of tray development described above is suitable for plates and flat film. (See Part II for roll film development and Part III for development of papers.)

★ Tank development

Advanced amateurs and a large number of professional photographers also prefer tank development, i.e. a prolonged development in a rather dilute solution. Plates and cut films are held during development in a vertical plane in slots or grooves in the side of a tank (the films are slipped into holders of stainless steel which slide into the grooves or clipped by the edges in hangers which are suspended in the tank). The time of development depends both on the degree of dilution of the developer and its temperature and upon the amount of agitation imparted to the solution. Development is speeded up as the temperature is raised or the developer concentration increased and vice-versa.

Tank development offers the advantages that the darkroom can be left while development is in progress or other work can be carried on in room light if the tank is provided with a light-tight lid and in addition it yields soft well-covered negatives.

Tank development has found many adherents among amateurs who use roll films. This is easily accounted for. When they only had orthochromatic material it was not very difficult to develop a roll film by the illumination of a red safelight. Panchromatic films, however, have to be developed in total darkness, or in very dim green light, or have to be desensitized first. At this time there accordingly appeared on the market small tanks for the amateur to use himself (Correx and similar types). It is only necessary to stay in the darkroom while the film is loaded into the tank in the proper manner and the lid replaced securely. After that it can be taken out of the darkroom and all the processing can be carried out by daylight. Developer is poured into the tank through a small opening which is protected by light trapping louvres. After an intermediate rinse or stop bath the developer having been poured off, fixer is poured in, and finally it is washed *in situ*, all in the same tank. In fact there are also

on sale a number of small tanks for amateur use in which the film can be loaded into the tank in daylight, this does away completely with the need for a darkroom for film development.

As a general rule special developers are used in these tanks such as 'Refinex' and for 35 mm. miniature films, 'Nogranol'.

★ Factorial development (Watkins)

Also used is the factorial method of development. It needs some experience and can only be used if conditions are always kept the same.

Factorial development is based on the fact that there is a fairly constant ratio between the time taken for the first signs of the image to appear after immersion in the developer and the time required to give complete development. This ratio is different for each developer and is called the development coefficient or Watkins factor. If, for example, for a chosen developer the first traces of the image show after 20 seconds and the Watkins factor for this developer is 12, the image will be fully developed after $20 \times 12 = 240$ seconds$=4$ minutes. The chief difficulty is to decide when the first traces of the image appear since the negative, particularly ultra-sensitive modern materials, cannot be brought very close to, or kept exposed for long to the dark red safelight. Obviously this method is impracticable for panchromatic materials which have to be processed in complete darkness or by weak green indirect illumination.

FIXATION

The aim

After development the emulsion contains reduced metallic silver and silver halide salts (such as silver bromide in negative emulsions and silver bromide, chlorobromide and chloride in positive emulsions).

The metallic silver in the form of a grey black powdery deposit constitutes the image. The silver salts, however, are still sensitive to light. So much so that if a negative or positive is exposed to light just after it is developed – even after rinsing – it will soon be completely fogged. The remaining undeveloped silver salts must, therefore, be removed from the emulsion. This process is called *fixation* because it fixes the image and so makes the negative permanent. During fixation the insoluble silver salts are changed into soluble salts which can be dissolved away in the wash water.

It is erroneously believed by some photographers that negatives are completely fixed when they are cleared of all milkiness. At this point there still remains about 5% of the less reactive silver salts still unconverted. To change these into the soluble form, so that they can be removed by washing, fixing should be allowed to go on for at least the same time again, i.e. for twice the clearing time.

★ Composition of fixing baths

The chemical most commonly used for fixing is *sodium thiosulphate*, generally called hyposulphite, 'hypo' or fixing salt. This is available in small pea crystalline form (pentahydrate) and in a powdered anhydrous form, this being used for packed fixing powders. It is prevented from caking by adding very small quantities of special chemicals known as sequestering agents.

The emulsion of developed plates and films and in addition with papers the paper base itself carries over into the fixer where it is released, a relative large quantity of developer.

To reduce this contamination of the fixer with the development products, developed negatives and positives are rinsed momentarily before putting them into the fixer.

When sodium thiosulphate alone is used as the fixer, however, this procedure will not prevent a number of difficulties. The developer absorbed in the developed emulsion layer proceeds to reduce the soluble silver salt complexes which are formed during the process of fixation (these silver complexes are directly reduced even without the action of light). This produces in the emulsion and on the fixing bath a precipitation of fine silver particles. In the emulsion this causes spots and various kinds of fogging and in the fixer a faintly cloudy condition which tends to turn brown.

As we have already seen, the reduction of silver complexes by developer can only take place in alkaline conditions. If the alkalinity retained in the negative is neutralized before fixation or at the same time as fixation takes place then all these faults can be avoided. In practice, therefore, only acid fixing baths are used, made so by adding substances to the sodium thiosulphate which give an acid reaction. For this purpose potassium metabisulphite or sodium bisulphite are nearly always used. It is, however, better practice to use a stop bath (see formulae G.351A and G.352) in which the material is placed after development and before fixing. In this way the developer is neutralized and rendered inactive before the material is immersed in the fixing bath.

Other substances are often added to the fixer: acetic acid, citric acid, chrome alum, potassium alum or sodium sulphite.

Acetic acid or *citric acid* are added to neutralize the alkaline developer accelerator. The development, which we have seen takes place only in alkaline conditions, is thereby stopped immediately. Such baths, which arrest development are called stop baths (see G.351A and G.352).

Chrome alum and *potassium alum* harden the gelatine (that is, they tan it so that it swells less). Hardening baths are very much used in the tropics and in temperate climates during the summer months, in fact they are universally used except where the alum acts as an unwelcome mordant for vegetable dye matter in some water supplies. It should be noted, however, that alum cannot be added just as it is to a fixing bath. It must always be used in conjunction with sodium sulphite or bisulphite; this solution is also tipped into the fixer (see formula G.305H). A separate hardening bath may equally well be used either before or after fixation (see G.354).

Sodium sulphite prevents the precipitation of sulphur in acid fixing baths. Precipitation is most likely to occur in summer when baths have been kept in use for a long period at temperatures above the normal. At such times it is particularly recommended to add sodium sulphite (see formula G.305).

The best method of fixing

As fixing proceeds, silver salts which are completely insoluble or only soluble with great difficulty in water may be formed. It is only in the presence of an excess of *active* fixing salt that a double salt which is readily soluble in water is formed. The bath must, therefore, be sufficiently concentrated and allowed to act for a sufficiently long time. Exhausted baths must be resolutely discarded. Fixing in two trays is recommended. The first tray (or tank) holds a used bath, the second a fresh one. When the second has been in use for some time the contents of the first should be thrown out and replaced by the second, this being renewed with fresh solution. To make the two trays easily distinguishable it is a good idea to have them of different shapes or colours.

Negatives may appear to be completely free of all traces of unexposed silver salts when they have lost their milky appearance. At this stage they should be left in the fixer for a similar period to ensure fixing is complete.



Photo: Harry Kerr

★ Rapid fixers

To speed up negative fixation, which is necessary or desirable for press work, sal ammoniac (ammonium chloride) can be added to the fixer. The addition of this salt does not, it is true, increase the amount of silver salts which can be fixed out by the bath but the speed of fixation is increased at least with emulsions which contain silver iodide. A suitable formula is G.304.

A number of proprietary rapid fixers have recently become available containing ammonium thiosulphate. These not only give much more rapid fixation by a factor between 5 and 10 times, but are claimed to have longer life and to fix more film than common hypo baths. They are more expensive, however, and if a hardener is required this must be compounded specially for use with them. They also will precipitate sulphur if exhausted or used at elevated temperatures.

Prolonged immersion in a rapid fixing bath will reduce a silver image, paper emulsions may also change colour, and fine-grained emulsions are particularly susceptible to their reducing action. If, for convenience, one of these rapid fixers is used the instructions should be followed carefully.

★ Chemical reactions of fixing

$Na_2S_2O_3 + 2AgBr = 2NaBr + A_2gS_2O_3$

Sodium thiosulphate + Silver bromide = Sodium bromide + Silver thiosulphate

$Ag_2S_2O_3$ is insoluble in water and cannot be left in the sensitive layer. With sufficient excess of sodium thiosulphate a further reaction takes place to form a double or complex silver thiosulphate salt which is readily soluble in water.

WASHING

After fixation negatives and positives must be thoroughly washed to get rid of the complex thiosulphate salts (soluble in water) with which the emulsion layer is impregnated.

Needless to say, the water should be clean and free from all organic matter and solid particles. Tap water is often contaminated with sludge and fine particles of rust especially at times of the year when the reservoirs are low or there is a sudden flush of water which prevents such particles settling in the tanks.

Fine solid particles are difficult to remove from emulsion layers once dried. A felt bag is very satisfactory for filtering water in which prints are washed, but more elaborate filter systems may be needed especially for washing miniature negatives. Filters containing activated charcoal are particularly valuable for removing organic coloured impurities which might otherwise stain negatives or prints.

In photographic processing most people tend to be more particular about developing and fixing than they are about washing. Because no visible changes take place during the period spent in the washing tank it is easy to believe that nothing can go wrong at that state. Many a photographer has discovered to his cost that although washing may not be one of photography's more spectacular operations, it is still a very necessary one.

Very few of us can afford to employ unlimited supplies of washing water, or at least to do so entails so much inconvenience that it ceases to be worth while. Generally speaking it always pays

Photo: Mario De Biasi →



to make the best use of every drop. And with any given supply the total washing time can be shortened by making more efficient use of the water.

The unwanted chemicals leave the sensitive emulsion during the course of the washing operation as a result of a physical phenomenon called *diffusion* in which dissolved substances tend to travel from areas of high concentration into those where the concentration is lower. A hot object, for example, will go on losing heat to its surroundings until both it and the surrounding objects arrive at the same temperature. In precisely the same way, the dissolved chemicals present in the unwashed emulsion continue diffusing into the surrounding washing water until the concentration in the emulsion and the water reaches the same value. The transfer of the chemicals into the water is quicker when the water is being constantly renewed in one or another of the ways described later.

There are two important factors in this process:

1. The amount of water present in terms of actual volume.
2. The movement of the washing water.

It is now clear from what has been said above that washing efficiency is goverened by three things:

1. the diffusion process; 2. the movement of the water; 3. the rate at which the bath is renewed. (We are not concerned here with the composition of the water or the effects of variations in the analysis – i.e. the amount and nature of dissolved or suspended impurities.)

★ The diffusion process

It is an elementary chemical law that the rate at which a chemical diffuses is proportional to the difference between its concentration in the solution and in the substance into which it happens to be diffusing. Sometimes there are other retarding factors, such as absorption, that tend to reduce the speed at which the transfer proceeds. These appear to exercise no influence on the removal of hyposulphite of soda and ferrocyanide salts from the negative emulsion, but on the other hand, in print washing, they show a definite retarding effect on the rate of diffusion, due to the cellular nature of the paper support. At the same time, the rate of washing is lowered where the negative or print has previously been through a combined hardening fixing bath – this is particularly so with a potash-alum bath. Raising the temperature of the washing water is another effective way of making the chemicals diffuse at a faster rate.

In practice then it is possible to reduce the washing period of the sensitive material as the temperature of the water supply to the bath is raised; a washing period of 30 minutes at a water temperature of 68°F. (20°C.), for instance, can be reduced to 20 minutes at 86°F. (30°C.), and conversely, the washing period must be extended to 45 minutes at 50°F.(10°C.). But excessively high temperatures must be avoided because they tend to cause swelling and blistering of the gelatine.

It can be shown that the greater part of the salts in the emulsion layer are eliminated during the early stages of the washing operation and that subsequently the remainder diffuse out at a much slower rate.

★ Agitation of the water

The agitation due to the normal inflow of the supply into the tank is not generally sufficient to keep a constantly changing layer of uncontaminated water in contact with the surface of the emulsion on the film or paper.

When washing is carried out in running water in a tank it is very difficult to ensure enough movement – and especially to make the movement uniform. It helps to direct the stream against the rim of the vessel in such a way that it sets up a circulating motion. Also, to produce the same result, the film or paper can be kept moving about in the tank.

In those tanks where the fresh water enters at the bottom and simply overflows at the top, or where the water enters at the top and is drawn off by a siphon or adjustable drain cock from the bottom, the effective movement of the water over the surface of the sensitive material is generally very sluggish.

With such tanks the washing efficiency can be improved by injecting air at the bottom of the

tank (preferably at several different points evenly spaced over the whole area) to agitate the whole volume of the water. A small circulating pump will produce exactly the same result. In this case it is important to note that a large tank calls for a really powerful circulating system.

When the total volume of water in use at any one time is small, it is easier and therefore cheaper to achieve satisfactory agitation. Under these conditions the water can also be used to better advantage.

Washing by spray ensures the maximum amount of agitation where the jets strike the surface, but such elaborate methods can only be employed in the large-scale processing of films or continuous lengths of film where the sensitive material is always kept automatically on the move.

★ Changing the water

To work out the required flow for a washing installation it is always necessary to take its effective volume into consideration. Its efficiency in terms of water used increases as the volume of the water standing in the tank at any one time gets smaller. To simplify the calculation we shall not consider the case of running water. When the job is to wash a number of small prints it is not a good idea to immerse them all at the same time in a large volume of water, but to pass them in succession through vessels containing smaller amounts of water. This fact is by no means always fully appreciated, but the following example will serve to show what an important influence it can have upon the efficiency of the washing operation. Suppose ten prints after fixing hold about 20 cubic cm. of fixer containing 20% of hyposulphite. If these prints are now immersed in a bath containing 10 litres of water, the most thorough washing cannot produce a lower concentration of hypo in the water and the emulsion than 0·04% of hyposulphite per litre. If they are immersed in 1 litre of water, the concentration will then be 0·4% of hyposulphite per litre. If they are removed and immersed in another bath, the concentration will be reduced 50 times – i.e. to 0·008% of hyposulphite per litre. A third bath will produce a concentration of 0·0016%, and so on. From this it will be seen that 3 litres of water, divided into three successive baths will give more complete washing that a single bath holding 10 litres. So it is possible to achieve efficient washing if the period of soaking in each bath is long enough – 5 to 10 minutes – to allow the concentration of hyposulphite in the water and the emulsion of the sensitive material to become stabilized.

The same result can be arrived at in tanks by emptying the tanks from time to time. This leaves the film uncovered for a short time, but the loss is more than made good by the complete renewal of the water in the tank.

The method of washing by spray, as employed in continuous processing plant, is altogether ideal on account of the fact that the water in this case is being constantly renewed. At the same time the consumption of water is considerable. In such systems the tanks must on no account be allowed to run permanently full or the principal advantage of continuous renewal of the water will be lost. An excellent system which is also economical is the arrangement known as a 'cascade washer'. It can be worked with four trays or tanks, for example, by using the water from the fourth change to refill the third tank, that from the third change for the second, and so on. Fresh water is used only in the final wash. The first washing water is, of course, the most contaminated, and the fact that it already carries a certain small amount of fixer does not matter. The sensitive material is left to soak for about five minutes in the first, second and third dishes in succession. The water must flow from the last tank into the first.

So, for effective washing, two factors are of first importance:

1. The volume of water involved must be kept as small as possible.
2. Thorough agitation must be used.

If washing is insufficient the salts left behind will crystallize out on drying and will later decompose and cause discoloured spots and patches and fading. Care should be taken to wash negatives, which have been hardened, for a longer time than unhardened negatives.

To check whether washing is complete, the potassium permanganate test can be used. Instructions for carrying out this test are given in Part V.

AFTER-TREATMENT

Images can be reduced and intensified when it is desired to reduce or increase their density or contrast, but no such after-treatment should be attempted on an irreplaceable negative or print until it has first been carefully copied, then thoroughly refix in fresh hypo, hardened if this has not already been done, and thoroughly washed. Blistering, frilling and reticulation and overall or patchy staining may otherwise be caused.

★ Reduction

The purpose of reduction is to make negatives which are too hard usable by reducing their contrast and in addition sometimes to render heavy negatives less dense so that they can be printed or enlarged with less exposure (i.e. in a shorter time). Reducers dissolve away some of the silver of the image but not all act in the same way, each type having a precise and different action. Farmer's reducer – potassium ferricyanide – (G.501) first acts on the areas of lightest density (the highlights) much more rapidly than the other areas. Permanganate reducer (G.502) has an action intermediate between these two types. It follows that G.501 should be used for over-dense and fogged negatives. It is incorrect to use it for negatives in which the shadows are clear or only lightly covered, for it is easy to see that since the action of this reducer is primarily to attack the lightest densities in the shadows it would cause these progressively to disappear. Negatives which are too hard but which have only light densities in the shadows, i.e. are correctly exposed, should be treated in persulphate reducer (G.203 and G.504).

Negatives between these two extremes – thick negatives, i.e. ones which have been over-developed, should be treated in permanganate reducer (G.502). This can equally well be used to reduce over-dense prints. It is possible to use for prints also a reducer containing potassium cyanide, but as this is exceedingly poisonous it is not recommended. (A useful reducer for local use on prints is the iodine-carbamide reducer available as a packed proprietary kit). All reducing action should be preceded by careful cleaning and washing of the negative. Remove all grease or fingermarks with a solvent such as carbon tetrachloride (e.g. 'Thawpit').

Note: Treatment in Farmer's reducer should not be prolonged past the point where the shadow densities are cleared. If the contrast is still too great continue the reduction in persulphate reducer.

★ Chemical reactions in reduction

Farmer's Reducer

$4K_3Fe(CN)_6 + 4\,Ag = 3K_4Fe(CN)_6 + Ag_4Fe(CN)_6$

Potassium ferricyanide + Silver = Potassium ferrocyanide + Silver ferrocyanide

$Ag_4Fe(CN)_6 + 2Na_2SO_3 = 2Ag_2S_2O_3 + Na_4Fe(CN)_6$

Silver ferrocyanide + Sodium thiosulphate = Silver thiosulphate + Sodium ferrocyanide

Silver thiosulphate dissolves in excess sodium thiosulphate to form a double complex salt which is soluble in water.

Persulphate Reducer

$(NH_4)_2S_2O_8 + Ag = Ag_2SO_4 + (NH_4)_2SO_4$

Ammonium persulphate + Silver = Silver sulphate + Ammonium sulphate

★ Intensification

The aim of intensification is to increase the image densities proportionately so that the heavier silver deposits are relatively more increased than the lighter deposits. The contrast is thereby increased. The process consists of changing the silver into some substance which gives a heavier density or to add to the silver some substance which stops the actinic light. Intensification is,

therefore, of most use with only weakly or under-developed negatives. In general intensification cannot be used to save hopelessly underexposed negatives, although if an increase in graininess is acceptable, negatives which have only received the minimum exposure, that is, their shadow densities are well down on the low contrast toe of the characteristic curve, can be made to produce prints with much better separated shadow detail on normal grades of paper by intensification.

The most commonly used intensifiers are the mercury and uranium intensifiers, and chromium is the most used in England.

Intensification with mercury is carried out in two stages: first *bleaching* in mercuric chloride solution during which a double salt is formed which remains in the emulsion layer as a white deposit, secondly, *blackening* the image with ammonia or sodium sulphite. After these two operations the image consists of an amalgam of mercury and silver.

Intensification with uranium nitrate overlays the image silver with a red-brown deposit which effectively stops the actinic light. It should be realized that fogged negatives will have their fog intensified. Negatives of this type should first be reduced with potassium ferricyanide (G.501) until the fog is removed before subjecting them to intensification.

If necessary the intensification can subsequently be removed. The negatives that have been treated with mercury should be immersed in a normal hypo solution and those which have been treated with uranium in a 5% solution of sodium carbonate.

The mercuric chloride solution will keep for a long time if it is only used on well-washed negatives. Uranium nitrate solution should be discarded after use.

★ Chemical reactions on intensification

$HgCl_2 + 2KBr = HgBr_2 + 2KCl$

Mercuric chloride + Potassium bromide = Mercuric bromide + Potassium chloride

$HgBr_2 + Ag = HgBr + AgBr$

Mercuric bromide + Silver = Mercurous bromide + Silver bromide

$AgHgBr_2$

Double salt

(white precipitate)

Blackening

$AgHgBr_2 + Na_2SO_2 + H_2O = Hg + Ag + Na_2SO_4 + 2HBr$

Double salt + Sodium sulphite + Water = Mercury + Silver + Sodium Sulphate + Hydrobromic Acid



The ballerina Helga Præedel – Photo: Siegfried Enkelmann

PART TWO

THE NEGATIVE

Taking the Picture
The Negative Material
Processing Negative Materials

TAKING THE PICTURE

HANDLING THE CAMERA

Learn to know your camera so well that you use it and your hands and eyes almost automatically: this for the expert photographer is the starting point for success. When buying a camera it is essential to go over the operation of the mechanism in detail together with the handbook and the instructions supplied with it. Follow this up by practising with the camera before it is loaded with film. It is best to handle the camera always in a fixed routine sequence of operations. A sequence adopted by many first class photographers is as follows: first set up the camera and select the subject and its position in the viewfinder or on the ground glass, then focus with the distance scale, the rangefinder or on the ground glass; then calculate the exposure with an exposure meter or a Gevaert exposure table; next set the diaphragm (stop) and the shutter speed, and cock the shutter if necessary, then for plate and cut film cameras withdraw the darkslide and then finally depress the shutter release gently. Do not forget to wind the film after each exposure. For plate and cut film cameras replace (or push back) the darkslide immediately,* remove it and replace the ground glass screen.

Do not try to make 'handheld' exposures of 1 or $\frac{1}{2}$ second duration. Handheld exposures are never sharp unless the exposure is 1/50th, 1/100th second, etc. The bigger the camera and the smaller the negative the greater the effect of camera shake on the sharpness of the negative. Success is possible with 1/25th second if the camera is held very steady, or steadied against something. Whenever longer exposures are necessary, as, for example, inside a building or under very thick trees, the camera must be used on a tripod or support. In some cases a table or some stable, immobile object can be used instead. When the subject itself is moving, too long an exposure time can obviously cause blurring.

THE EXPOSURE TIME

As a general rule the shutter speed needs to be shorter as the speed of the subject increases. Basically all that counts is the actual speed of movement of the image across the sensitive surface (or across the ground glass). It follows from this that other things being equal the shutter speed required to 'stop' motion also depends on the position of the camera relative to the movement of the subject. If, for example, a moving train is being photographed and it is moving directly across the image plane, i.e. perpendicular to the optical axis of the lens, it will be

* Many professional cameramen reverse the darkslide to indicate that this film or plate has been exposed. Always use slides in numerical order if at all possible, or keep a careful note.

necessary to use a much faster shutter speed than that required for a train which is travelling obliquely with regard to the optical axis. It is worthwhile memorizing the fact that if the subject is moving obliquely (above 45° or less) to the axis the exposure time can be doubled. If the subject motion is along the optical axis it can be four times greater. There is given below a table showing for different subjects in 'motion' the speed in miles per hour and the shutter speed required to stop motion when they are at various distances from the camera.

Exposure times for moving subjects

(in fractions of a second)

Direction of movement *perpendicular* to the optical axis

Subject	*Approx. Speed m.p.h.*	*Camera – subject distance* 5 yd.	10 yd.	20 yd.	30 yd.	50 yd.	100 yd.
Snowflakes	1	1/200	1/100	1/50	1/40	1/20	1/10
Swimmer	3	1/400	1/200	1/100	1/75	1/40	1/20
Pedestrian	3–4	1/500	1/250	1/150	1/100	1/50	1/25
Horse – walking	3–5	1/750	1/400	1/200	1/150	1/75	1/40
Rowing boat	4–7	1/1000	1/500	1/250	1/200	1/100	1/50
Trotting horse	10–13	1/2000	1/1000	1/500	1/400	1/200	1/100
Sailing boat	10–20	1/3000	1/1500	1/750	1/500	1/300	1/150
Runner or jumper	13–17	1/3000	1/1500	1/750	1/500	1/300	1/150
Cyclist (normal)	13	1/2500	1/1250	1/750	1/400	1/250	1/150
Raindrops	13–20	1/3000	1/1500	1/750	1/500	1/300	1/150
Waves (normal)	20	1/3000	1/1500	1/750	1/500	1/300	1/150
Skater	20–27	1/4000	1/2000	1/1000	1/750	1/400	1/200
Cycling race	20–27	1/4000	1/2000	1/1000	1/750	1/400	1/200
Goods train	27	1/4000	1/2000	1/1000	1/750	1/400	1/200
Motorboat	27–40	1/6000	1/3000	1/1500	1/1000	1/600	1/300
Scooter or motorcycle	40	1/6000	1/3000	1/1500	1/1000	1/600	1/300
Racehorse	33–40	1/6000	1/3000	1/1500	1/1000	1/600	1/300
Motorcar (normal)	50	1/8000	1/4000	1/2000	1/1500	1/800	1/400
Waves (storm)	50	1/8000	1/4000	1/2000	1/1500	1/800	1/400
Express train	70	1/10000	1/5000	1/2500	1/2000	1/1000	1/500
Racing car	100–130	1/20000	1/10000	1/5000	1/4000	1/2000	1/1000
Express electric train	100	1/15000	1/8000	1/4000	1/2500	1/1500	1/750

Notes: The table above does not take account of any movement of the subject itself. If it is desired to show clearly every part of the subject (for example the hands and legs of a marching man move with twice the speed of the man himself) the shutter speed will have to be increased.

Sometimes the negative will be unsharp even though the speed has been set to the value calculated or read off the table. In such cases the shutter speeds should be checked and the method already outlined can be used to do this.

★ A practical system

To decide quickly what shutter speed to use for every type of moving subject the following rule is suggested:

Rule: For a subject at 10 yards the shutter speed should be 1, divided by the speed of the subject in miles per hour and multiplied by 100. For a subject at 20 yards reduce the speed to twice as

long, at 40 yards to four times as long, and at 100 yards to ten times longer and so on. This rule applies to a subject moving perpendicularly to the optical axis of the camera lens – which will always be the least favourable condition.

Example: To photograph a cycling race just at the point where the contestants start to climb a hill, and their maximum speed at this point will, it is estimated, be 10 m.p.h. They will be travelling obliquely towards the camera. What shutter speed should be used? At a distance of 10 yards the shutter speed should be 1/1,000th second, at 20 yards, twice this, i.e. 1/500th second. Since, however, the subject is approaching obliquely (about 35°) the shutter speed can accordingly be reduced by a factor of two to 1/250th second. If the subject is moving away from the camera the shutter speed can be further reduced to 1/150th second.

Note: This rule does not take any account of the movement of parts of the subject itself. If you want to show clearly the legs of the racing cyclist the denominator of the fraction must be at least doubled. The exposure time will, therefore, be 1/1,000th second at 10 yards. In practically all cases the rule given can be used without any corrections, especially as, generally speaking, there is no need, except in experimental or scientific photography, to 'freeze' the subject. On the contrary a slight blurring caused by the movement of the limbs and parts of the mechanism helps in conveying the illusion of movement and of life and helps considerably to heighten the suggestion of action. If this rapid method of setting the shutter speed is adopted as a routine habit it will require hardly any time at all to work out what is necessary in any particular situation for a mathematical derivation of the rule given above.

LIGHTING

The character of a photograph as well as the clarity with which the details are shown depends principally on the way it is lit. If the lighting is uniformly flat, as is the case when the sun is directly behind the camera, the picture will lack depth and roundness. To give an impression of depth some variations of light and shade are essential, and this is only possible if the source of light (e.g. the sun or a studio lamp) is to one side of, below, above, or behind the subject. Each of these lighting effects is shown in the examples of lighting methods reproduced on page 112.

Daylight – outdoors

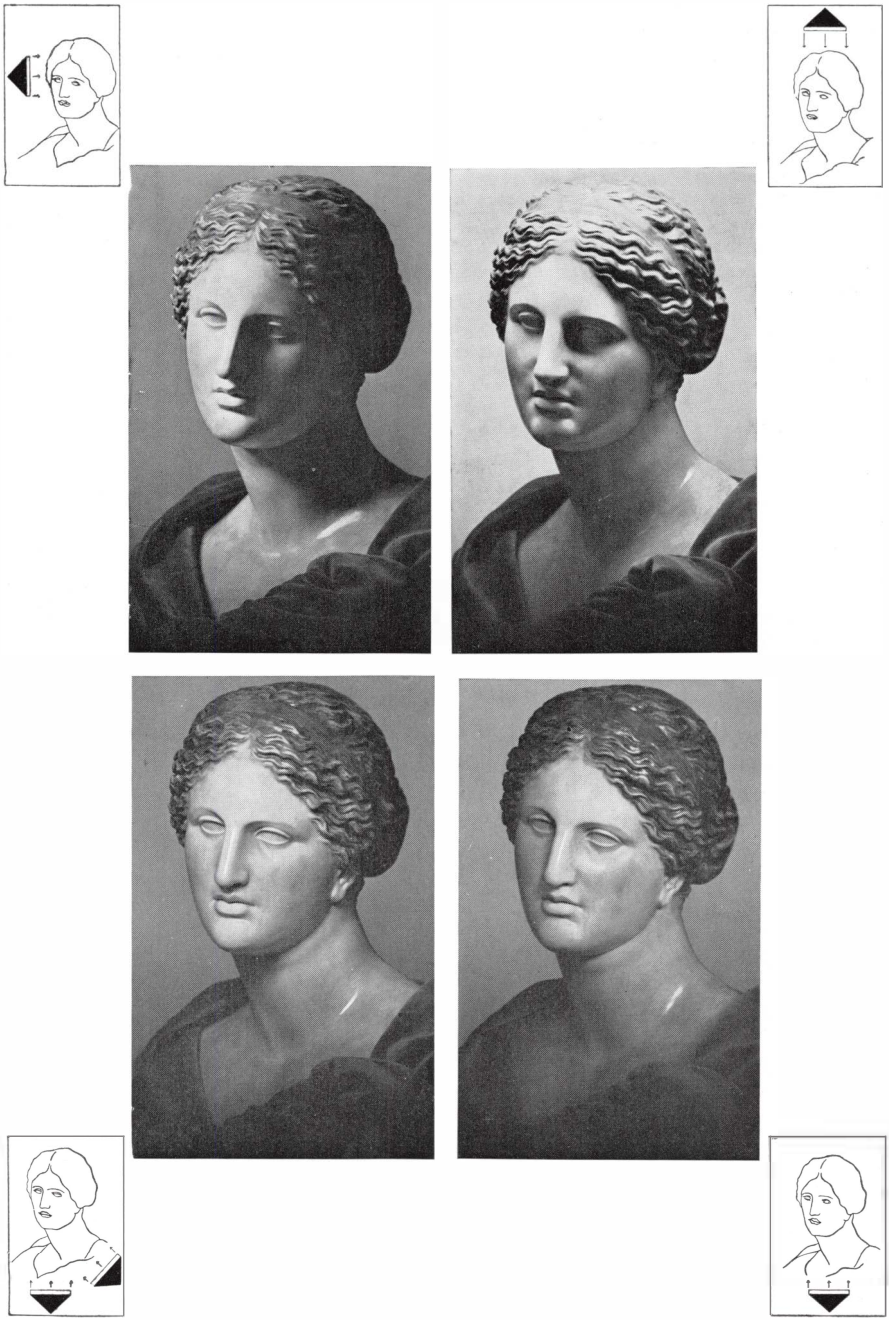
The sun is the natural source of light. On clear days the light falls directly on the subject giving what is called 'direct illumination'.

All the other light falling on the subject comes originally from the sun but does so *indirectly*. It is made up of radiation reflected on to the subject from the blue sky, from clouds, from the surrounding objects (the ground, walls, water, trees, etc.).

Direct light naturally is the strongest. It is chiefly responsible for the level of lighting and for the relief effect. This light is called 'Main light' or 'Key light'.

If only this single source is used the shadow parts of the subject which are unlit will appear just as dark as does the unlit portion of the moon when we look at it when it is not full.

When we are photographing outdoors and we see the shadows are well illuminated with their details well shown, this is due entirely to the reflected radiation, to diffuse light. This lighting which is always less powerful than the main light is generally called, in photography, the 'fill-in light'. The lighting



Several ways of lighting a subject, using one or two lamps

contrast of the scene, which is more properly called the brightness range, is determined by the relative intensities of these two sources of light.

Outdoors these facts are in principle more or less constant and incapable of being changed. If the range is too great for the emulsion to record despite shortened development time, the photographer will have to try to lighten the shadows by using a reflector such as a white sheet, or a sheet of white card, plain or covered with silver paper. Such methods are, however, restricted to subjects of reasonably small size, e.g. portraits. In such cases a flash lamp can also be used ('synchro-sunlight'), but this means bringing into use a new method not contemplated under this particular heading. Remember these facts: sunlight gives two types of illumination, the direct or main lighting and fill-in or general lighting. The lighting contrast of the subject depends on the ratio of these two sources. This ratio is greatest in fine weather (sunshine with blue cloudless sky) and can fall to a value of 1 for overcast conditions.

Artificial light – indoors

Modern industry has provided the professional photographer, the press photographer and the amateur with highly developed methods of lighting which enable them to operate quite independently of daylight and to take their pictures at any hour of the day or night. It does require, however, knowledge and experience to make the best use of these light sources.

Except for those cases where special effects are being sought, the problem is simply how to reproduce as closely as possible the effect of natural light. In order to know how to light a studio it is best to find out how objects are lit naturally. The conclusions we come to from this search will serve as a guide to us in controlling artificial light sources. The equivalent to the direct or main light of the sun is provided by a lamp which gives the main light. If this lamp can easily be moved about, the photographer can, by watching carefully the result produced, arrive at any effect he desires.

To light the shadows (fill-in light) reflected light from the main source can be used deflected on to the subject by means of a reflector or a mirror, which takes the place indoors that the clouds or surroundings play outdoors. This method is somewhat restricted since the fill-in light can only be varied within rather narrow limits. A better alternative, therefore, is to use a second lamp which can, by adjusting the brightness through a resistance and distance, be used to control the degree of shadow illumination within very precise and close limits. In principle it can be said, however, that on examining the combined effect of these two light sources, the effect of natural light outdoors is missing. To produce this a third source must be introduced to light the background. This third lamp can, in addition, be used advantageously to remove or suppress any shadows cast which are often undesirable.

In this way, with three lamps, the effects of natural sunlight can be reproduced – provided, however, that the subject is not too large.

We talked above about the brightness ratio. This is of great importance, as

the capabilities of the emulsion are strictly limited. For ordinary black and white photography this ratio ought not to exceed 1 : 3 and for colour work 1 : 1·5. Larger ratios are often quoted for both types of work, but these are for special effects and in experienced hands. In colour work, from which colour prints are to result, the 1 : 1·5 ratio is strongly recommended. If two similar lamps are in use together, make sure that their respective distances from the subject are such that the lamp further away (fill-in light) is not, for black and white, more than $1\frac{3}{4}$ times, and for colour, not more than $1\frac{1}{4}$ times the distance that the main light is away from the subject (e.g. for black and white 6 ft. and 10 ft. 6 in., and for colour 6 ft. and 7 ft. 6 in.).

The size and types of lamp and the size and type of reflector alter the nature of the lighting very considerably. Fill-in sources can be long white troughs fitted with several bulbs with shades to prevent direct light from the lamp falling on the subject, or a light-walled studio can be lit with many indirect sources. Main lights can be flood type or optical mirror or lens spotlights and, since the intensity of these can be very high, they need careful use if a balanced lighting ratio is to be achieved. In general it should always be remembered that the human eye readily accepts a far wider range of brightnesses than can the photographic negative and transparency, and above all a photographic print on paper, in fact the human eye finds it difficult without much careful training and experience to adjust the lighting ratios within those fine limits which yield the most pleasing results on the paper prints. It is, therefore, a golden rule, when beginning, to keep the lighting ratios and degree of development low, otherwise no photographic paper of low enough contrast will be found on which to print the results without excessive handwork on the negative or shading when making the print.

Intelligent use of, and precise adjustment of, the lighting ratios is absolutely indispensable. The best method is that which is generally used in the large professional studios. Starting with a very low light level the main light is brought up and measured with a light meter. Next the fill-in light is brought in and checked similarly with the meter until the shadows are sufficiently bright. Artificial lighting allows extraordinary effects to be obtained, e.g. lighting from below such as one can observe in the theatre, dramatic lighting, exaggeration of contrasts, etc. A fourth or more lights can be added to the basic three to pick out certain parts of the subject (e.g. a headlamp for lighting the hair in studio portraits). What has to be learned is how to use all these lights in combination to achieve any desired effect.

Types of lighting available

★ Studio lamps

The photographer has at his disposal in the studio two main types of lamp: spotlights which produce a collimated or directed light beam, which can generally be adjusted from a broad to a narrow angle, and floodlights which produce a diffused general light. This diffusion is increased for instance by

covering the floodlight with a diffusing screen, of muslin or matt plastic, or by shining it on the ceiling or walls, etc. Spotlights are used for main lights or for picking out details, floodlights for fill-in and shadow illumination.

To light the background either a floodlight or a spotlight can be used according to the effect desired. The actual lamps used are frequently special high-output ones, run at voltages higher than is normal for domestic bulbs with consequently shorter working life. Two types of lamp are generally available: photoflood lamps, No. 1 of 275 watts and two hours' life and No. 2 of 500 watts and six hours life, giving an initial output of 7,500–8,500 lumens and 16,000–18,000 lumens respectively, according to the type and voltage used (see the makers' catalogues for further details). Since their working life is short these are mainly used by amateurs and, in cases where their high output for colour work is essential and convenient (medical colour work, cinephotography and high speed photography and television, etc.).

Professional photographers in general use type B lamps of 500 watts, which have a useful life of nearer a hundred hours, as they are run at a lower temperature, and giving an initial output of about 11,500 lumens; in spotlights special filament lamps are used similar to those used in slide and cine projectors, except that in the larger powers of 1, 2 and 5 kW. much sturdier bases and larger glass envelopes and filament supports are used to allow the lamps to be moved without breakages. Practically all the lamp manufacturers list lamps which can be used together with the two types of light source described above for use in floods without giving 'mixed colours'.

★ Photoflash bulbs

In recent years, for interior snapshots and for press photography and for professional studio colour photography, flash lamps have gained considerable and ever-increasing popularity. These lamps are generally made of fine shredded aluminium-magnesium wire or foil enclosed in a glass bulb filled with oxygen and fired by an electrically ignited primer. Some small bulbs have only a small quantity of pyrotechnic paste inside the envelope. They are available in a wide range of sizes, colours, bases and characteristics to suit all types of user and all modern cameras are normally provided with some means of fixing them. These lamps have one great drawback - it is not possible to observe beforehand what effect the light is going to give on the subject – but the photographer finishes up by becoming quite accustomed to this state of things, and imagines the final result with astounding expertise in certain cases, being able to employ several different lamps (multi-flash).

Magnesium photoflash bulbs

★ Their time-light curve

To be able to use flashbulbs properly, a knowledge of their characteristic time-light curves is desirable. As an example the curve for a commercially available lamp, the PF5, is shown here (fig. 47).

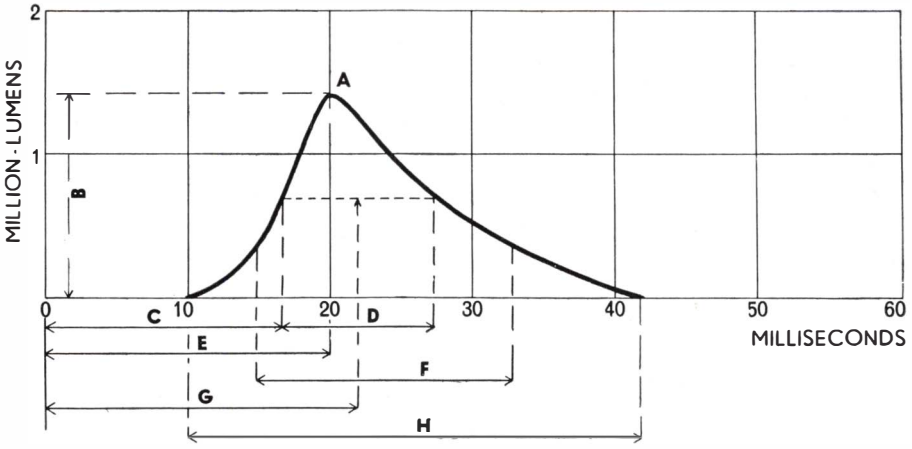


Fig. 47 Time-light curve of a photoflash bulb.

A=Peak

B=Light output (peak value): the point where the light output reaches its maximum value.

C=Firing delay: the time between application of the firing pulse and the point where the light output reaches 50% of its peak value.

D=Duration of flash at 50%: the length of time during which the light output is more than 50% of the peak emission.

E=Time to peak: the time between the firing pulse and the peak emission of light.

F=Working flash duration: the length of time between the accumulated light output reaching 5% and 95% of the total integrated emission.

G=Average delay: period between start of firing pulse and the mid point of the period during which the output is more than 5% of the peak output.

H=Total duration.

Along the horizontal axis is plotted time in milliseconds and along the vertical ordinate the luminous output in lumens. The curve shows the value of the light output as it varies with the time. On the horizontal scale the making of the firing contact is shown at O. The foil or wire starts to burn somewhere about 10 milliseconds (1 millisecond = 1/1,000th second), after the firing contact is closed. The peak emission of about 1·4 million lumens is reached after 19 to 20 milliseconds – a time that has been standardized for a large number of flash bulbs and designated by Class M – thereafter it falls away progressively until it is practically burnt out after 40 milliseconds.

To make most effective use of the light output of the lamp when the whole flash is not used the 'fully-open' position of the camera shutter must be timed to occur during the period when the emission is above 50% of the peak (i.e. during time D). On the curve above this period runs from 17–27 milliseconds and, therefore, is equal to 10/1,000 = 1/100th second.

★ Synchronizing shutter and flash

Let us see how the synchronized flash photograph is taken.

The simplest way is as follows: set the shutter to B (=bulb), open the shutter, fire the flashbulb, close the shutter. With this system, which is called *open-flash*, the actual exposure depends on how long the shutter is left open if there are bright lights in the picture and is about $\frac{1}{2}$ second or more, and the whole of the light output from the flashbulb is used. Its advantages are that any type of flashbulb can be used – its disadvantage, that it can only be used in darkness or very feeble light unless the subject is not a moving or live one.

If, however, we are using a between-the-lens shutter there are several ways of arranging for the desired synchronization. Those most commonly used are:

A. The camera shutter is fitted with an X contact

With this type of synchronizer the fully-open position of the blades occurs just about at the point where the lamp is fired – that is at point O on the horizontal axis (fig. 47).

This type of contact is often fitted to the simpler types of shutter, such as those that are pre-set. This type of shutter reaches its fully-open position about 10–15 milliseconds after operating the release. However, since with such shutters it is difficult to guarantee precise and consistent synchronization between the firing and release, a shutter time of 1/25th second is generally recommended. With this method of synchronization practically all the light output is used. Each square of the diagram is equivalent to 10,000 lumen-seconds (a domestic 100 watt bulb emits about 2,000 lumen-seconds each second). The X contact cannot be used for shorter exposure times (1/100th second, and less).

When the X type of synchronization is fitted to between the lens shutters the firing circuit is not made until the shutter blades reach the fully-open position, that is, until about 5 milliseconds after the shutter is released. With a shutter time of 1/25th second all the light from the flash is used, with a setting of 1/50th second only the rising part of the light output will be used.

B. The camera shutter is fitted with an M contact (Synchro-Compur, Prontor SVS, etc.)

With this type of shutter, which requires to be cocked before firing, the time to fully open is about 5 milliseconds, but the built-in flash contact is made some 13–15 milliseconds before the blades start to move, so that the total delay between pressing the release and the shutter opening to its full extent is from 18–20 milliseconds. The photographer is thus able with this system to make use of the peak of the curve even at high shutter speeds. Many modern shutters are fitted with X and M contacts.

C. The apparatus is fitted with an F contact (mostly French apparatus)

The firing circuit is closed at point O on the curve, but the synchronizer is arranged so that the shutter does not start to open for a further 4–5 milliseconds.

D. The camera shutter is fitted with FM contact

This allows one or more positions intermediate between F and M synchronization so that whichever is more suitable for the type of bulb in use can be selected.

In all the systems of synchronization described above, which generally speaking are fitted internally in the shutter, the delay between the electrical circuit being made and the shutter opening is either fixed, or if it is adjustable then only between rather narrow limits.

There are, however, a number of types of synchronizers in which this delay can be varied and which can, therefore, be used with different types of both bulbs and shutters. The best known of these in the *solenoid synchronizer*. This type has a solenoid connected in parallel with the flash bulb. The current fires the bulb and simultaneously energizes the solenoid which produces a magnetic field which moves an armature linked to the shutter release lever. The actual delay depends on the position of the armature in the solenoid. If the position is adjusted the delay can be altered as desired.

There is also the *electromagnetic synchronizer*. In this system a magnet is energized by the same current that fires the lamp. The magnet operates a latch which releases a spring driven piston attached to the shutter release. The travel of the piston is adjustable and allows the delay between firing and shutter release to be regulated. As the shutter release is moved by the spring the electromagnetic synchronizer requires less current than a solenoid synchronizer.

There are also a wide variety of purely mechanical synchronizers in which some mechanism regulates the delay between the firing contacts being closed and the release of the shutter. This type has the advantage that no electrical energy is required except to fire the lamp so that a small battery can as a rule provide sufficient current.

★ Synchronizing focal-plane shutters

In cameras fitted with this type of shutter the negative is exposed through a slit which moves from one side to the other in front of the sensitive surface. As a consequence it is necessary, as already explained, to distinguish between the exposure time at any given point and the total time during which the slit is traversing the film.

If the shutter is set to give say an exposure time of 1/1,000th second, the width of the slit and the spring tension must be adjusted so that each point on the sensitive surface is exposed for exactly 1/1,000th second. If, for instance, a miniature (24 × 36 mm.) camera is used with a slit width of 2 mm. it must traverse a distance of 2 mm. in 1/1,000th second. If it sweeps the long dimension of the film it must, therefore, take 36 : 2 = 18 milliseconds to traverse the whole length of the film frame. The total exposure time is, therefore, 18 milliseconds or nearly 1/50th second.

A glance at the time-light output curves for the flashbulbs we have discussed above will serve to show that none of these can be considered suitable. To be usable for this purpose the flashbulb must have a curve with (i) as long and flat a peak as possible; (ii) a gradual rise along the curve to compensate for the acceleration of the slits – the most advanced designs of focal-plane shutters are fitted with some anti-acceleration or constant slip speed devices. As regards (ii), however, it should be noted that this gradual rise is only necessary for roller blind shutters in which the acceleration is not compensated for in the apparatus, by for instance increasing the width of the slit as it accelerates. Generally speaking, it must be admitted that variations of 2 : 1 in exposure across the negative are difficult to detect visually.

To allow total exposure times of about 30–40 milliseconds, special flashbulbs have been developed and are generally sold under the name of 'long-flash' or 'long-peak' flashbulbs. Curves

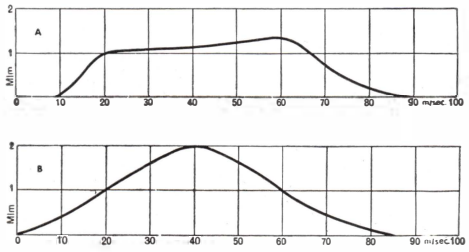


Fig. 48

Time-light curves of 'long-flash' flashbulbs.

for two different types are shown here (fig. 48). The first type (A) has the two characteristics mentioned above, the flat portion is about 40 milliseconds, the time during which the light output exceeds 50% of peak output is more than 50 milliseconds. The second type (B) has an extended form of the normal curve. Its time above 50% peak is 40 milliseconds. Such lamps are generally used with large focal-plane shutter cameras. It is clear that as compared with cameras fitted with between-the-lens shutters they make very inefficient use of the light from the flashbulbs. Although the total light output in lumen-seconds is high, such shutters cannot be used when small stops are useful or indispensable – such as for press work. It is because of this that many press cameras, besides having focal-plane shutters, are also equipped with between-the-lens shutters. Before the advent of flashbulbs focal-plane shutters were favoured because fast shutter speeds of 1/1,500th and 1/2,000th second were possible for action photographs of sports, racing, etc., and flash-powder burnt generally with sufficiently long duration. Modern between-the-lens shutters of medium sizes go up to speeds of 1/500th second, in one case 1/800th second.

Some of the more expensive modern 35 mm. miniature cameras (24 × 36 mm.) have focal plane shutters with slit transit times of 10–25 milliseconds. With such blind travel times the normal type of rapid rise high peak flashbulb can quite properly be used – such as curve B in fig. 48. In any case most of these cameras use slit widths which approach the film frame width so that at the slower shutter speeds (1/20th–1/30th second) the *whole* of the focal plane is exposed for long enough to use a fast peaking synchronized flash.

Most modern miniature cameras are fitted with integral synchronization. With bigger apparatus the synchronization should be set so that the slit starts to expose the plate at the start of the flat peak of the light output curve. When the shutter starts off slowly (inertia) it is generally satisfactory to fire the bulb and release the shutter at the same time.

★ To start using a synchronizer

A word about starting to use a synchronized flash system. These are generally provided with a battery. In recent years a system which uses a 22·5 volt battery in conjunction with a condensor has become increasingly popular (capacitor flashguns).

There are a number of simple testing methods which are described in the literature devoted to this subject. If the synchronizer does not work properly the first thing that should be checked is the battery and then the shutter. The smallest piece of dirt or grit between the shutter blades can slow up their movement and as a result throw the synchronization out.

★ Deciding on the exposure time

To decide on the correct exposure with flashbulb *guide numbers* are used (see Table O, Appendix I).

A guide number is the product of stop number and distance of the flash from the subject. The number depends on the number of lumen-seconds actually

utilized. If a long exposure time is used, say 1/5th second, all the light output of the flash is used to expose the emulsion layer, with short exposure times on the other hand (e.g. 1/100th second) only a limited amount of the light output is effective. The guide number, therefore, depends on the exposure time whenever this is shorter than the time required to use the full light output from the flashbulb. A table of guide numbers for 'Gevapan 33' film used with the flashbulb whose given curve is shown in fig. 47 (PF_5) is given below.

Example: Suppose we want to photograph a subject on 'Gevapan 33' at a distance of 12 ft. from the camera and flashbulb and a shutter setting of 1/100th second. What stop shall we require if we use the M contact?

Exposure Time *second*	*Guide Number* *aperture(×ft.)*
1/50th	250
1/100th	180
1/200th–1/300th	130
1/400th–1/500th	100

From the table the guide number is 180. This is the stop number multiplied by flash distance, so the guide number 180 is divided by 12 (ft.) the distance to give the stop number. This is, therefore, $180 \div 12 = f/15$.

The smaller flashbulbs commonly used by amateurs are somewhat less powerful. These have guide numbers for 1/100th second of round about 100–130.

For such flashbulbs the stop would be $\frac{100}{12} = f/8$ and $\frac{130}{12} = f/11$.

To give a smaller diaphragm opening, the distance should be reduced.

At 8 ft. the apertures would be $\frac{100}{8} = f/12{\cdot}5$ and $\frac{130}{8} = f/16$ (approx.).

Note: Guide numbers as given in the table are strictly only applicable to average conditions (normal type of reflector, and average reflectivity of subject and surroundings), with the flash on or near the camera.

For dark subjects or for subjects in dark surroundings the aperture should be opened by one or two stops; for light subjects taken in light surroundings use an aperture one stop smaller.

If the lamp is not on or near the camera but is nearer 45° to the optical axis the aperture should be opened one stop. The value of the guide number also depends upon the developer and the method of development used. Before commencing any large quantity of work it is as well to carry out a few preliminary trials. If it is found that the aperture needs to be opened up one stop to get the negative quality desired then the working guide number should be multiplied by 0·7. A guide number of 260 then becomes $260 \times 0{\cdot}7 = 180$. Similarly, if the aperture needs to be closed down one stop multiply the guide number by 1·4.

If two lamps are used, one being to lighten the shadows, the aperture should be closed down half a stop.

Electronic flash lamps

This type of flash lamp is becoming so popular that it may eventually supplant the metal foil flashbulb when the disadvantages which are holding back its full exploitation (weight and size, danger) have been completely overcome.

The electronic flash lamp comprises a flash tube helical or inverted U in shape filled with a rare gas (Xenon or a mixture of Xenon and Krypton) at a reduced pressure which is caused to emit a brilliant flash of light by rapidly discharging a condenser through it, between the two tungsten electrodes. The discharge is triggered by an auxiliary condenser (trigger condenser) which ionizes the gas filling and makes it conducting. The system is charged from an accumulator or a dry battery, the direct current being converted to alternating current by a vibrator and then transformed to a suitably high voltage. After rectification the charge is stored in the main condenser until it is discharged to give the flash when the trigger condenser is fired by the synchronizer. In the more recent equipments the voltages used on the tubes are only 250 or 500 volts and these can be obtained directly from packs of miniature voltaic pile type batteries without the need for intermediate conversion; this results in great simplification, lightness and economy. For many professional purposes, however, the convenience of a mains supply is preferred and batteries are dispensed with.

The duration of the flash varies from 1/1,000th–1/10,000th second for the new low voltage equipment; using electrolytic condensers the flash duration can be as long as 1/250th second above 50% peak. Even when the fastest possible shutter speeds are used the whole of the flash is effective, so the guide number for any particular film is fixed.

Since the flash occurs almost instantaneously, there being no significant interval between the trigger pulse and the peak of the flash output, only the X flash contact can be used.

Only that exposure time – 1/25th or 1/30th (according to the type used) – at which the *whole* of the film in the focal plane is uncovered before the trailing shutter blind starts to close over the film can be used with focal plane shutters. The manufacturers' published information should be consulted about the number of flashes obtainable on one charge, or from one set of batteries and for other information.

Because of their extremely short duration flash high voltage types of electronic flash have the useful property of being able to arrest fast moving subjects and of reducing loss of definition due to involuntary camera shake. Perfectly sharp pictures are much easier to obtain.

Supplementary flash lamps can easily be coupled up to the main flash.

It should be particularly noted that softer negatives will be obtained with electronic flash than with flashbulbs because of the very short duration of the flash. This difference is reduced with the newer portable longer duration electronic flash lamps.

Most modern lamps filled with Xenon emit light with a colour balance (temperature) very close to that of 'mean noon sunlight' (5,200–5,800°K.).

For colour photography these lamps can be used with 'Gevacolor Reversal' daylight film without the need for any correction (see Part IV).

Emulsions for use with flash

For black-and-white work any of the 'Gevapan' films can be used. For high speed work (sport, press) 'Gevapan 36' film is particularly recommended.

Practical suggestions for using flash

1. The importance of the reflector is often overlooked. Even the most rudimentary reflector doubles the effective light from the flash. It follows that by using a properly designed reflector much greater intensities can be produced. A flash fitted with a reflector suitable for the normal lens gives generally about



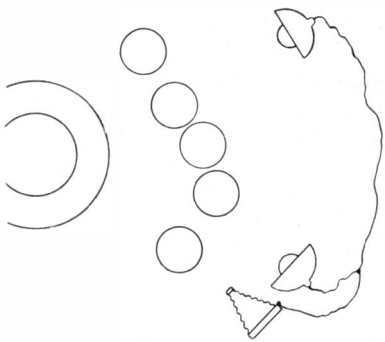


Fig. 49 Distance of flash lamp in reflector from Christmas tree, 10 ft. Distance from camera to tree, 6 ft. Exposure: f/22–1/25th second, 'Gevapan 33'. The white wall reflected the light strongly so that the faces of the children in front of the tree were outlined with a light halo. Their attention was diverted from the photographer by lighting up a bright star on the top of the tree.

9–10 times the brightness on axis, without excessive fall-off to the sides of the negative. On removing the reflector therefore the guide number should be *divided* by 3. Some reflectors allow the degree of diffusion of the light to be adjusted. If compact subjects are being photographed the light may with advantage be concentrated, and conversely with wide-angle shots of large size (such as groups, etc.) the light must be spread as widely as possible.

Remember that small flashbulbs give sharp hard shadows, to produce softer results the reflector should be fitted with a diffusing screen and a number of small flashguns for the small PF1 capless bulbs are fitted with a plastic protective and diffusing screen which hinges to one side to permit the flashbulb to be changed. A number of them are available commercially. In an emergency a thin handkerchief can be pressed into service.

2. As far as *placing* the light is concerned, when it has to be on the camera it is best positioned above the lens.

To get the very best results with a single flash it is by far the best arrangement to light the subject slightly from one side and to 'lift' the shadow side either by putting the subject near a light coloured wall, or by using a reflector of some kind to throw some light into the shadows. This will give a much livelier lighting. To do this the flashgun head will have to be connected to the camera through an extension cable.



Fig. 50 Flash at camera.

The subject can also be lit indirectly by pointing the flashgun at the ceiling – that is if it is reasonably light in tone – this is called 'bounce flash' and requires generally two to three stops wider aperture than the exposure calculated from the guide number by taking the distance from the flashbulb to the ceiling and back to the subject.

If subjects of considerable depth are being photographed it is important that the depth should not exceed more than a quarter of the distance between the flash and the nearest part of the subject.



Fig. 51 Flash placed inside the lampshade using an extension cable. No flash at camera. The effect is certainly much more natural.

3. An interesting technique is that called by the Americans 'synchro-sunlight', in which contrasty daylight or sunlight in which the shadows are very dark is used in combination with the light from a synchronized flash to lighten the shadows, especially when strong against-the-light effects (*contre-jour*) are being attempted. It is particularly useful when colour prints are wanted, since it reduces the brightness range of the subject to within the range that can be satisfactorily reproduced. To decide the correct exposure balance proceed as follows: first determine the correct exposure by daylight alone, suppose this is 1/50th second at *f*/8. Divide the appropriate guide number, say 130 by 8 to give 16 ft. This calculation gives the correct distance for the flash to be exactly equal to the intensity of the sunlight. It follows that if the photograph is taken with the flash at 16 ft. the shadows will completely disappear. The flash must

therefore be moved further away – say to 20 ft. to give a negative with sufficient lighting contrast. If this is difficult or inconvenient the reflector can be removed (giving a flash distance of 20/3 = 7 ft. approx.) or the flash can be covered with a



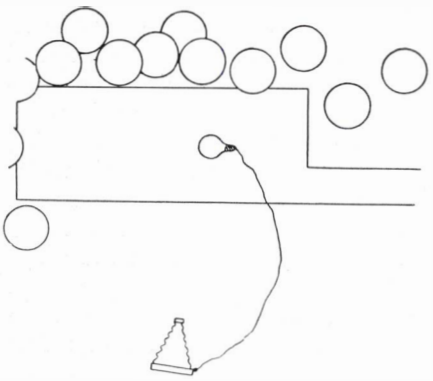


Fig. 52 A large flash bulb was placed inside above the window. Lack of any reflector resulted in very contrasty lighting. The lamp was placed about 6 ft. from the children and connected to the synchronizer on the camera by cable. A large flash was used so that the stop used could be small enough to eliminate for all practical purposes the ambient daylight outside which would otherwise have given unwanted reflections in the glass. For the daylight alone the exposure would have been 1/25th second at f/11, that used here was 1/25th second at f/32.

diffusing screen (or handkerchief) which will reduce the light to the desired amount. In general the smallest bulbs are satisfactory for this application, especially in daylight portraiture, blue flash bulbs must, of course, be used with daylight colour film.

Linkebeek (Belgium) – Photo: E. Sergysels →

4. A second lamp can be plugged into the synchronizer through a special connector if the flashgun is not provided with a socket for an extension flash. The flashbulb used should be of the same type (either blue or clear) as the main light. The second lamp is usually placed to the side of and closer to the subject (accent light or key light). The relative lamp distances should be such that the lighting contrast should not exceed the range that the film can accommodate.
5. If very large subjects are being tackled it is often necessary to use a large number of bulbs. The flashbulbs are distributed so that they themselves are concealed from the camera position and are arranged to give as even illumination as possible. The synchronizing cables should not be of thin wire if long lengths are used otherwise their additional resistance will affect the synchronization. Professionals have special boxes using accumulators, or large dry cells and heavier leads for multiple flash work.
6. If a portrait is being taken in dim light by open-flash technique, it is advisable to illuminate the face of the subject with a pocket torch to keep the irises of the eyes opened up otherwise the pin-point irises characteristic of earlier electronic flash portraiture will be obtained. Even with open flash it is generally possible to accommodate some general room illumination to keep the subject happy and natural.
7. Some makes of flashbulb are supplied with a blue safety spot on the glass envelope. This spot is a cobalt salt and is put on the inside of the glass. If air leaks in through a crack or fault the blue spot turns red due to the humidity and the lamp should be discarded.





Photo : George Pickow

COMPOSITION

We have seen in the preceding chapters how to produce a sharp image and what means we have at our disposal to decide precisely the best exposure to give. It has been necessary to dwell on these points because a sharp image and a properly exposed negative are the two indispensable prerequisites for obtaining technically satisfactory photographs.

A technically perfect photograph is, however, not necessarily an attractive one. The fastest film is useless if you yourself are unmoved by the beauty of your subject. A photograph ought to have some meaning, it should attract both by its content and because of its form; it should seize the attention and hold it. For those who wish to pursue the matter further it can be stated that anything is potentially suitable subject matter for a photograph, even the simplest things. It is one of the great merits of amateur photography that it helps to reveal beauty in the most ordinary object, both to those who take photographs and those who look at them.

The art of composition concerns itself with the study of forms, that is the interplay of line and mass. If a picture or an exhibition print is studied one cannot help but see how the attention is immediately drawn to the subject; each part of the image is brought into harmony with the subject by the design and the tonal arrangement; everything which could distract the attention from the subject is rigorously excluded; and the whole gives a pleasing impression of balance and order. A photograph which exhibits these characteristics is said to be well composed.

Even if you have no wish to take exhibition photographs you will still find it an advantage to follow some simple rules, which will be a great help to the amateur and to others in making better photographs. Moreover, as we have no intention of making the matter unnecessarily complicated, we shall use examples mainly to illustrate the points we wish to make.

The first and most important thing about a photograph is that it should present a definite subject, and that it should present a single subject. If a group of people are taken then try to get them together so that they form a group which is clearly separate from their surroundings. If the photograph shows action, for example, a group at play, it is best if all the persons shown are taking part in the game, or indirectly as spectators watching the play. In such a case good lighting and also, if possible, the correct placement of forms will help to give a plastic separation between the group and the background.

The second important condition is that the light and shade should be so divided between one side of the picture and the other that they are very nearly balanced. The photograph should not be unduly 'heavy' on one side, it should be in equilibrium.

On the following two pages examples of both these principles will be found.

The way in which the subject is placed within the rectangular picture and the way the rectangle is divided is also of importance. This is known as framing. If the subject itself is placed precisely on the middle of the print the eye does



The reader will agree with us that it is a pleasant picture. What immediately strikes one is the lovely shimmering light in which the dark, though well-detailed trunks stand out clearly against the brilliant contrast of the shining foliage. Sunlight pours gently down into the glade. But if we study the composition of this print it is not completely satisfying. The light and shade are not distributed equally between the two halves of the picture. It 'leans' to the right. The unity desired is spoiled. The eye wants to travel from the bottom left towards the end of the lane, but is also attracted by the light areas to the right. The whole effect is slightly disturbed. This fault is easily overcome by dividing the picture in either of the ways shown below. →



See how unity and balance have been obtained. The eye, starting in the foreground, traverses the picture smoothly to the end of the avenue of trees. If the skilful photographer who produced this print had wished to show this portion particularly he could have included one more tree on the right to help to hold the picture more strongly. He could equally well have suppressed some of the foreground. The art of composition is above all the art of 'what to leave out'.



Here, too, the two parts of the image have been brought into balance. Notice particularly how the trees have been ranged so that they run closely parallel to the diagonal of the picture. This arrangement is known as 'diagonal composition'. It gives a feeling of force, which fits in perfectly with the massive trunks. When a subject is found which suits this type of composition be careful not to place the subject exactly along *the diagonal. The effect of the composition should be felt without realizing that it was deliberately sought after.*

not know in which direction to go after it has looked at the subject. If, on the other hand, a larger area is left to the right or to the left of the subject and, if the eye is drawn there by the play of lines and forms or by a 'recall' or 'echo' or 'foil' of the subject itself, the eye takes in the rest of the image without hesitation or shock.

From what has been said it can be seen that aesthetics are based as much on logic as on feeling. So it may, perhaps, be possible to deduce the rules of composition by detailed analysis of the way an intelligent and perceptive observer looks at and assimilates a work of art. Even the born artist can derive some benefit from analysis of his work and from trying to discover what rules govern composition.

The amateur when he is a beginner is apt to imagine that all that is needed to make a good picture is to photograph a beautiful subject.

He all too easily forgets that much of what pleases the eye in reality has no such effect in a photograph. It is necessary to learn to see through the camera's eye. A camera with a ground glass focusing screen is ideal for this purpose, especially when beginning. The use of a viewer has much to recommend it. This is a rectangular piece of blue glass or celluloid – its shape corresponding to that of the film or plate in use, through which the subject is studied. If it is the same size as the actual film, i.e. $2\frac{1}{4} \times 3\frac{1}{4}$, then hold it a distance away from one eye equal to the focal length of the lens in use. If this proves awkward then have a proportionally larger piece held at a proportionally greater distance, i.e. for a 5 in. lens on the camera with the above film size the 'viewer' will need to be $4\frac{1}{2}$ in. $\times 6\frac{1}{2}$ in. in size if held 10 in. from the eyes. The blue of the glass reduces the brilliance of the colours to an almost monochrome scale so that the attention can be concentrated on the tonal masses, the lines and the shapes.

People can be used in the foreground provided their poses and clothes harmonize with the subject as is the case for the picture shown below. Their absorbed attitude shows they are deep in contemplation of the scenery and thoroughly permeated with the atmosphere of their surroundings. The three dark patches that their heads make introduce a rhythm and at the same time accentuate the depth of the picture. The curved backs echo the shapes of the mountains and make what we may call a plastic counterpoint. The picture is composed with a true feeling for the interplay of lines and tonal masses and it has a complete and harmonious cohesion.

Photo: Ergy Landau



Observation of things around us in this way cannot fail to reveal many subjects which would otherwise pass by unobserved. It helps to establish a habit of planning each picture beforehand and a methodical approach. There are available so-called 'pan-vision' filters which were used extensively by cine cameramen in the days of black and white work. These reduced the scale of tones to a range of purplish greys and were intended to give relative brightnesses similar to those recorded on panchromatic film.

Experience has shown that some groupings and positions have greater impact and attraction than others, as for instance the line of a diagonal, a triangular composition, and the S line. Examples to illustrate this assertion are better than

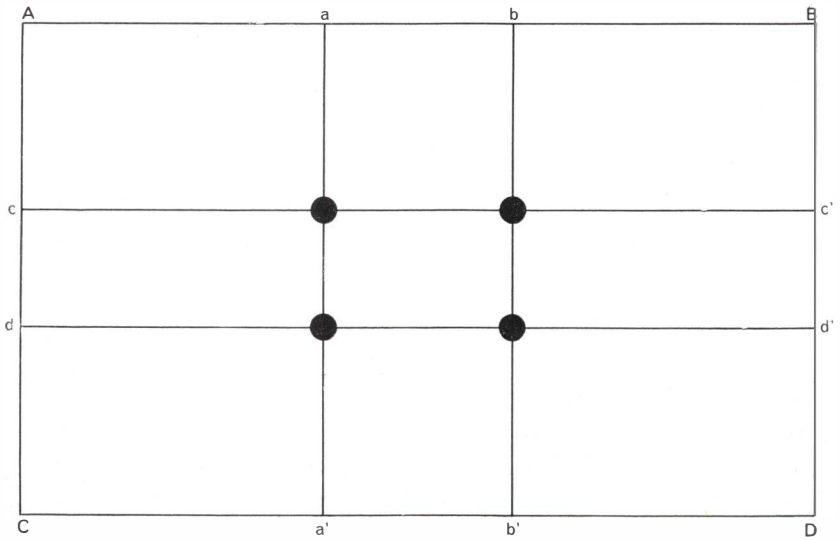


Fig. 53 The Golden Mean.

a long explanation. Too obvious a use of these patterns however should be avoided. The 'diagonal' is a skew line which does not necessarily run from one corner to another, the 'triangle' should not be too regular and the 'S line' should not be too apparent.

Another principle which the ancient Greeks are said to have formulated, considers that the placing of the most important parts of the picture at points where lines dividing the vertical and horizontal sides into three (or even into five) intersections yields an arrangement which the eye finds most satisfactory. Such arrangements are known as 'the golden mean'. A line is divided into the golden mean when the longer part is the geometrical mean between the shorter part and the whole line. The division is, therefore, into two parts in the ratio 1 : 1·618.



For example we have the point *a* in fig. 53 dividing the top line of the rectangle so that $\frac{Aa}{aB}=\frac{aB,}{AB}$ or $Aa.AB=(aB)^2$.

The black dots are called the 'strong points' of the picture. Remember here too the intention must not be too obvious. A further question of importance: what exact position should the picture be taken from? Many amateur photographers are too easily content with the stereotyped 'eye level' or 'waist level' view. The photographer who wants to make fine pictures cannot afford to be fussy, he will have to crawl on his knees if necessary and to try one viewpoint after another, high and low, according to the needs of the case. The subject should be examined closely through a viewfinder or on the ground glass from one side and then the other, and the search continued until the best viewpoint has been found.

If there is foreground in the picture this should not be allowed to overpower the objects in the distance just because the camera is closer to it. The camera should be moved closer or further away from the foreground material until the image is found to be satisfactory.

In taking subjects in motion the taking position cannot naturally be chosen at leisure, but the more one practises with still subjects the more easy it becomes to choose the best position for quick action shots.

A note to finish up with about upright and horizontal views.

When should we take a vertical position and when a horizontal or landscape view?

Everything depends upon the nature of the subject and the impression it is desired to produce. A wide gentle landscape is best shown with a horizontal format, because the horizontal line suggests tranquillity.

A vertical line on the other hand produces an impression of force. A vertical format is always advised when it is desired to convey a feeling of life, vigour, vitality and happiness. Such instructions should not of course be followed rigorously, but they are of considerable help in some cases.

One further suggestion: visit photographic exhibitions and salons, visit picture galleries and let your eyes absorb all they can. You must see and understand how the great masters composed their pictures and strove always to convey a feeling of something in reserve. Not of course to imitate them, since this can only have harmful effects, but above all to mould your taste and help you to find your own characteristic style. The essential thing is practice.

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The picture opposite shows how, by the use of carefully chosen lighting, the eye can be made to go immediately and without the slightest conscious effort straight to the heart of the subject itself. The remainder of the picture is kept in subdued tones. From the little girl the eye runs along the line from the head to the two foxes, wanders over the wall picture and returns to the child, along the cast shadow into the white and so on. Note how smoothly these eye movements occur and how much this helps to strengthen the particular atmosphere which emanates from the subject. This is the whole art of photography. It is hardly a question here of this precise positioning but of the impression of an inner tranquillity which has captured the maker of this picture and which he has likewise succeeded in passing on to capture those who look at it with open eyes and willing recognition.

Photo: W. J. van Borselen



'Practice makes perfect' and only by taking photographs and analysing one's successes and failures can one become a photographer.

Landscape

The photographer, with a feeling for the beauty of nature, is attracted to landscape work from the start. And anyone who goes on an outing, however short, will generally be pleased to be able to make an attractive picture or so in the course of the journey.

In landscape it is not all the things we see that attracts us most, but the atmosphere and the feeling that these objects arouse in ourselves.

To capture this 'inner feeling' in our pictures requires more than straightforward technical competence. The photographer must be able afterwards to distinguish from his other feelings that particular emotion which he experienced there and which caused him to take the picture. That is why, like other artists, he will find it desirable to recognize and to take account of those things which arouse in him any particular emotional response. He should remember that vertical lines are expressive of force, gravity, solemnity; horizontal lines repose; oblique lines or curves, pleasure, movement and grace. He will then be able to see which lines he should allow to dominate his composition to evoke and retain the impression desired. And this applies not only to lines but also to areas. Large heavy masses are appropriate for solemn grave subjects, light masses engender happy and light-hearted feelings.

An overall light tonal rendering expresses delicate fine and tender feelings. 'High key' is the term often applied to photographs of this type (i.e. a preponderance of light tones). The photographer must be on the look out to arrange the lines of the subject so that at first sight the areas of light and shade cause the attention to be led immediately to the point desired and from there to follow what has been called the 'line of entry' as we have discussed in the preceding chapter.

See that your picture says something, or that it makes you feel something, that it has some *significance* and that this significance is depicted in such a manner that those who see your picture can understand what you want to say. To do this every picture should have a theme, and one theme alone. This theme must be given substance by the play of lines and masses. The ground glass image should be studied carefully, the camera position selected with care and with due regard to the composition, taking into account the lighting and the tonal values.

Try to evoke a feeling of space: a good foreground, trees, a fence, a plough, an animal, you will find very useful. The foreground can just as well be represented by a person provided he is looking at the landscape and not the camera. Choose for preference one of the local people so that his or her clothes and pose fit in with the landscape.

←

It is not difficult to find the golden point of this powerful character study. The right eye, comprising as it does the area of greatest contrast, coincides with a 'strong point'. The author, an eminent photographer, was in all probability quite unaware of this fact, which only proves once more that the true artist handles his aesthetic balance with instinctive understanding. The theory of the golden mean was only put forward after exhaustive analysis of the works of the great painters. *Photo: Lucien Lorelle*

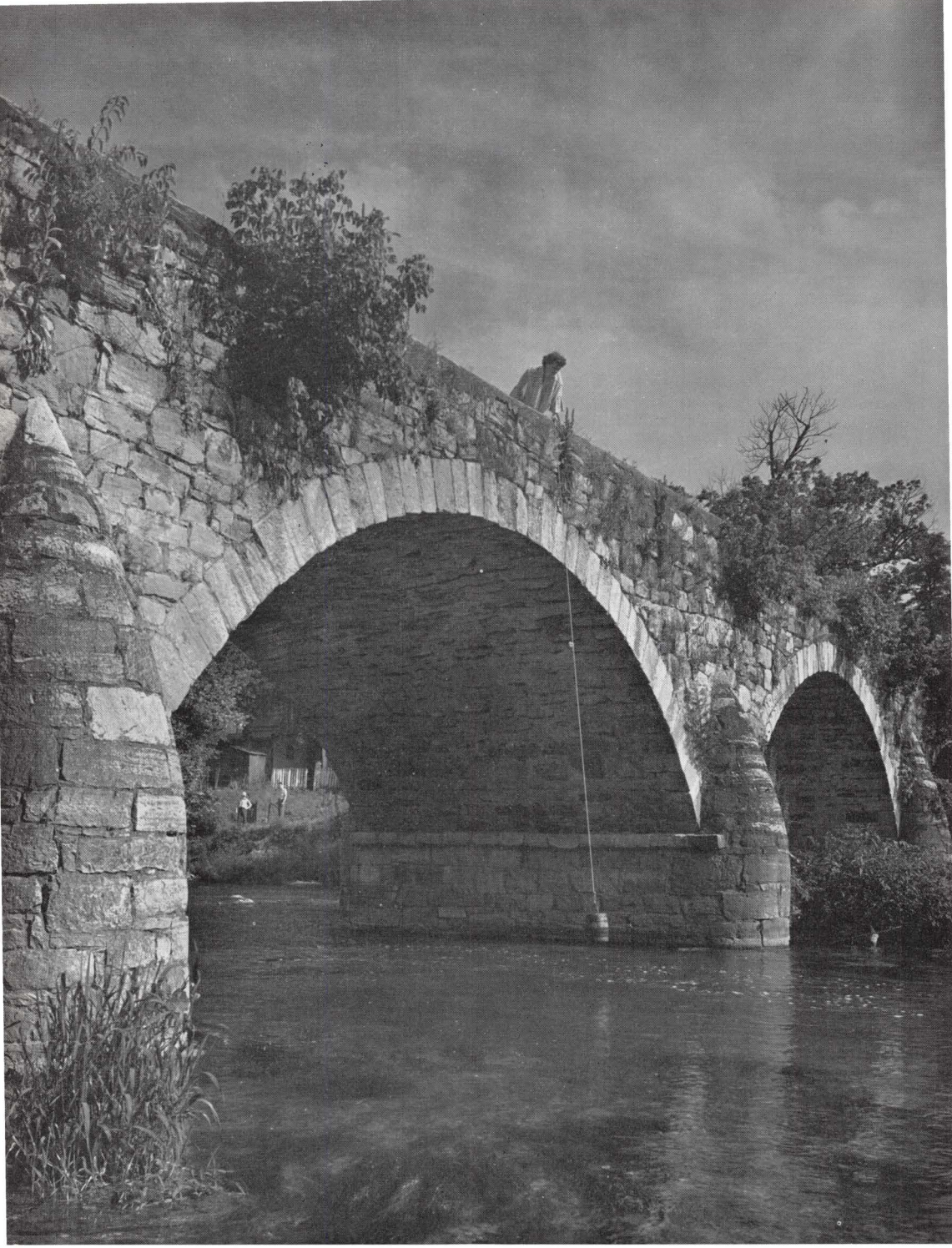


Photo : A. Aubrey Bodine

As a general rule you will be more pleased with landscapes with people in rather than without them, especially if they are doing something which is appropriate to the setting, such as peasants gathering in the harvest, or engaged in some other farming activity. It is wise, however, to decide whether the activity *or* the setting is the most interesting feature and to let one or the other dominate conclusively.

Guard continuously against hackneyed or bogus subjects. Subjects such as a straight road bordered by straight parallel trees have been overdone and have lost their impact; a house, a street, a village with modern villas, all these are too ordinary and uninteresting to merit the expenditure of a film or plate unless they can be transformed by viewpoint, selection or emphasis. But a winding road with a border of trees which wind and rain have fashioned into weird shapes and attitudes, a derelict hut, an old village where the leaning houses are crowded round the church, all these are motifs which the photographer can fashion into the most delightful pictures.

A perfectly symmetrical subject will make a monotonous picture unless it can be transformed by viewpoint and lighting, or set to one side of the frame. Never position the subject exactly in the centre, set it as a rule a little to one side. If, for instance, it is a house surrounded by trees see that these are not distributed evenly on either side. Try not to let the line of the horizon cut the picture exactly in half. A low horizon accentuates the sky and clouds and makes foreground objects appear larger; with a high skyline the opposite effect is produced and the attention is directed to the foreground and things look smaller.

The need for a contrasting foreground is most strongly felt with panoramic views. The impression of space and depth is strengthened. The foreground is only the means to an end. It should not be too obtrusive.

Once more may we repeat that you should avoid placing someone straight in front of and looking straight at the camera because this is a mistake which too many amateurs continue to make.

Be ready too, for it is very important, to take the picture at the best moment. this is just when the light shows the lines and shapes to best advantage. With landscape where the lighting and atmosphere play a preponderant part the best times to work are for preference early in the morning or late afternoon. Long shadows, and the aerial perspective given by light mists evoke a feeling of space and lend life and movement to the countryside.

As far as aerial perspective is concerned it should be mentioned that the use of filters, especially deep ones, is not always to be advised, especially if panchromatic material is being used. It is also wise to remember that quite a small amount of mist visually may have a preponderant photographic effect, and considerable experience is required before the landscape photographer can be certain of what effect he will be able to capture successfully.

★ Camera

For artistic landscape work, which seeks to portray the beauty of the countryside and which allows the photographer to express himself in terms of the country, and to display his temperament and philosophy, a camera with ground glass screen is the best, preferably a reflex, because



Photo : Le Roy Roselieve

this gives an upright image of the subject. This type of camera can equally well be used for 'reportage' photography, although a miniature camera with viewfinder is generally preferred for this type of work. A number of modern 35 mm. miniatures are equipped with reflex viewing upright and correct way round, and these may be found of use. The amateur will generally find that the discipline necessitated by the larger heavier and slower camera has a salutary effect upon his picture making.

★ Lenses

A relatively wide angle (short focus) lens will help to increase the illusion of space. In most cases it is essential to have a selection of lenses of different focal lengths, including telephoto lenses. The type of lens to be used depends upon the view required, and on personal preferences, but the beginner should be warned that telephoto lenses operated from great distances have a pronounced flattening effect unless this is counteracted by differential focusing or atmospheric effects or filtering. Conversely, a wide-angle lens exaggerates local differences of size and gives a notably dramatic if sometimes distorted effect.

A photographer who wants to make as impersonal a record as possible will generally prefer the clarity and bite of an anastigmat whereas one who inclines towards an atmospheric rendering will choose an older lens, either with adjustable diffusion, or an uncorrected type of aplanat or rapid rectilinear landscape lens, in which the aberrations distort or modify the image in a characteristic and often pleasing manner, often resorting finally to using a 'pinhole' instead of a lens.

The atmospheric results which characterized the Hungarian school of a few decades ago, were produced by light diffusion *in the camera* since the highlights were spread luminously into the shadows – an effect which cannot be achieved by diffusion at the enlarger unless an intermediate copy negative, which can be a paper negative, is employed. For atmosphere these results, which are not now very fashionable, have never been surpassed.

★ Tripod

Whenever importance is attached to securing a good composition, a sturdy stable tripod is indispensable. Not only does it facilitate a careful and thorough examination of the ground glass but it allows, where necessary, long exposures to be made at small stops; with modern high speed films small stops can be used with handheld reflex cameras of medium and large size, i.e. 1/200th second at *f*/22.

Pictures in towns and villages

Town and country life offer the photographer who is on the look out plenty of interesting subjects. Each place has its own particular character and there are special occasions such as fairs, fetes, religious celebrations, parades, etc., in which the local life is shown in the most picturesque forms.

On such occasions everyone, young and old, joins in. The amateur who wants to take advantage of this opportunity of making pictures needs to have a camera which can be handled quickly and easily as the most interesting little scenes are not only fleeting but unexpected. Above all, act quickly and positively, in order that as far as possible the people being photographed have no second thoughts. An auxiliary right-angled viewfinder which allows the photographer to shoot round corners will be found very useful in such cases.

Town and village, at normal times, however, will offer plenty of opportunities: humble old houses, small twisty lanes, parks and public squares, people at their work, farm life, etc. Here as well it is best to photograph people in their natural everyday poses and as far as possible without their being aware of it. In this

way you can take pleasant series of photographs which will go together in a series under such appropriate titles as for example: *The fete at A*, *A tour of St Martin's Church*, *Harvest at B*, *Spring in my village*, *C in the rain*, *Winter at D*, *Life in our road*, *Back to school*. It is easy to see that you will not lack subjects.

To finish up with a series of pictures that hang together successfully from a photographic point of view it is best to start out with a plan of work so that you can then decide the time of day at which each picture should be made to show the subject in the best light. Look back at what has been said in the preceding chapters to refresh your memory of what has been said about the technique to be followed for taking satisfactory shots with life in them.

Sports and pastimes

Photography is particularly in its element in the depiction of sporting subjects. No other graphic technique certainly is capable of registering with the same logical precision as can photography of a scene which takes place at speed. Taking satisfactory and characteristic sports pictures demands skill and experience, which is rarely purely photographic. Every sport has its own experts and it is wise for the photographer to have a pretty complete knowledge of the sport that he wants to record. Such sports as football where the centre of action moves rapidly from one place to another without anyone knowing in advance which way it will go requires quite a different camera technique to, say, high jumping, which all takes place in a restricted area, or to racing where the exact track that the running will take is known in advance. When the number of different sports there are is considered, then the work of the sporting photographer is bound to arouse our admiration.

From what has been said it is obvious that it is possible to lay down only a few general rules for sports photography.

To start with a camera with fast shutter speeds is essential, for example, for horse racing and motor racing.

The press photographer usually has a camera with focal-plane shutter, speeded up to 1/1,000th second and also, so that these speeds can be used, a wide aperture lens.

Naturally most pressmen are experienced users of flash, which makes it easier for them to secure their pictures under unfavourable lighting conditions and to 'freeze' movement just as they please. Press photographers are often reproached with carrying this technique a little too far, but it should not be forgotten that their photographs as a result reveal many details which otherwise would be quite lost.

A sports type finder is usually preferred as this allows the moving subjects to be followed easily. It is made of two frames, one rather small with a hole in it to which the eye is put, and a larger one through which the subject is observed and which outlines the frame of the picture; also popular for this type of work is the reflecting frame or 'Albada' optical type of viewfinder in which a white frame is

The American athlete Stanfield at the start of a race between Switzerland and the U.S.A. at the Neufeld Stadium (Berne) in 1950 – Photo: Walter Studer→

placed optically round the area which is being photographed. The wire frame despite its bulk and fragility is the most useful.

When it is impossible to get reasonably close to the subject a telephoto, or long focus, lens is advisable. For use with these a miniature camera has many advantages.

Amateurs with ordinary folding cameras need not entirely give up the idea of taking sports photographs, but they should confine themselves to subjects which are not moving too rapidly – for example, running, football, high jumping, etc. In such cases take care to choose moments in the action where the movements are not so fast, such as 'peak' moments as the movement is about to change direction, or to shoot obliquely rather than from the side.

Above all, do not forget that the faster the motion the further away you must get to get a sharp image. As far as the viewpoint is concerned you will often find that a low camera position is to be preferred – for example, high jumping or a racing car going 'flat out' will be most impressive outlined against the sky. A yellow filter will be worthwhile here.

One of the most essential things about good sports photography is learning to master your shutter speeds. If the speed is too fast then the subject lacks any feeling of motion or speed and loses its vitality. Obviously here experience is the best guide. It is quite a commonly used device, especially with very fast subjects such as racing cars close to, to swing the camera with the subject – this blurs the background while keeping the image sharp. There are numerous refinements



according to whether the focal plane shutters travels vertically or horizontally, and the precise distortion required in the shape of the car image, but handled with skill it is a powerful method worth trying out.

Architecture and sculpture

This type of subject can be treated in two different ways, depending on whether an artistic impression is required or a straightforward record. Most record workers consider their work, properly handled, has the purest attributes of art and the former group are sentimental and affected. In the first type of work to reproduce accurately all the details of the subject is considered by the photographer less important than to convey the impression that it has produced on him. His work therefore becomes a photographic re-interpretation.

In the second type of work a perfectly sharp reproduction of all the details is essential. It must be admitted that this requires just as much good taste and feeling for good composition.

Great care should be taken with the perspective and to ensure an even distribution of sharpness throughout. The particular conditions under which he has to work makes it necessary for the photographer who specializes in record work of this nature to adapt his technique accordingly.

A frequent fault is a building or a statue which looks as though it is falling over. To avoid this the sensitive surface of the film or plate must be perfectly vertical at the time of photography.

Outside the realm of pure record photography, however, it goes without saying that vertical lines in the subject need not necessarily be shown as vertical lines in the photograph; the photographer is quite within his rights in ignoring such general rules if he wants to produce a particular effect. It is worth remarking here that the convention of non-converging verticals, for such it is, is one that is confined to amateur photographers exhibiting in salons, and to the more conservative photographic schools. No one denies the skill and devotion behind this work but it is sufficient to say that artists and architects, who take and use photographs in their work, do not recognize a convention that allows and even requires horizontal lines to converge in the distance, but vertical lines to remain strictly parallel. It must be admitted that such projections are useful however for mensuration.

★ Camera

For preference no smaller than quarter-plate ($4\frac{1}{4}$ in. × $3\frac{1}{4}$ in.), if possible, half-plate $4\frac{3}{4}$ in. × $6\frac{1}{2}$ in.). It is imperative that all the movements are capable of being locked up solid with no 'ricketiness'. Since it is often necessary to use rising or cross front a focusing swing back with a full set of movements is indispensable. A ground glass ruled in squares is of great assistance in keeping the verticals parallel. The lens panel should move in all directions, up, down, to left or to right, and should be removable so that the lens in use can be changed. A large number of such cameras, some of which are very fine examples of the cabinet maker's art in teak or mahogany and lacquered brass, can be bought quite cheaply, and are still being made. Modern versions in metal and plastic, mostly but not exclusively in the 4 in. × 5 in. size are also available. In the hands of a professional who is capable and is provided with suitable means for correcting his verticals, and other distortions when he is enlarging, the miniature camera can give quite satisfactory results, provided a tripod is generally used and the best technique is employed.

 Part of the pulpit of St. Andrew's Church, Antwerp – Photo: A. A. Van Uffelen →



★ Tripod

Stability and lack of 'whip' are the chief requirements of the tripod. It ought also to be made so that the camera can be used in any position without the controls being fouled. If it is not provided with interchangeable rubber feet, or with automatic leg holding struts a useful addition is a 'spider' of three pieces of hinged wood, three chains or cords with which to hold the legs on stone or polished floors. Some people also tie heavy weights to the tripod to increase its stability, especially in a wind.

★ Lens

Lenses should be high quality anastigmats capable of covering the plate into the extreme corners even when a rising or cross front is used. They must also be completely free of focus shift on stopping down as in dim light the camera needs to be focused at full aperture, whereas the lens needs to be stopped down for depth of field during the actual exposure. Wide angle and long focus lenses are essential, the first to permit buildings to be photographed in the entirety, in restricted places, the second to get close-up views of details that are out of reach. A telephoto lens can also be used when the subject is too high to be taken with an ordinary lens except from an angle which gives an unpleasant perspective. Using a telephoto lens the picture can be taken from further off from a less acute angle and with a much better perspective.

★ Setting up

The camera should be correctly horizontal. Some cameras are fitted with a spirit level for this purpose. Always use a lenshood, even indoors. Some methods of holding the tripod legs (spider, chain or strap) is useful on a slippery floor. To help focus accurately in dark locations use a hand torch, switching it on at suitable locations to focus on instead of the subject.

Portraiture

Portraiture is a difficult subject to master.

As with other things, however, there are a number of rules which should be observed if satisfactory results are to be achieved.

The face should be lit *softly* by light coming from one side and as close as possible to 45° (and 45° above). Lighting from directly in front or above or below gives inferior modelling to the face.

Harshness is the principal fault to be avoided in portraiture; be very careful not to place your model in direct sunlight, unless you soften it or intend to balance it with a flash. Much experience is required before it is realized that contrasts that appear attractive to the eye are far too harsh on a print even when the negative development is cut. The most attractive portraits, even though they appear quite contrasty, are generally characterized by the most delicate gradations on the skin itself, especially in the lighter tones.

A portrait must be *natural* both in pose and expression. They can be taken out-of-doors or inside. Outdoors with clear sky the light is often too strong, too directional and too vertical, tending to give flat pictures devoid of relief. It is best under such conditions to put the model under some shelter or under trees. If the sky is cloudy then the modelling on the face will be more delicate than in sunshine.

Better results will be obtained in the early and later hours of the day than at midday. The advantages of working outdoors are shorter exposures and surroundings which promote natural expressions and poses. Conversely indoors

Photo : Dr Steinert →



the exposure has to be a good deal longer and it is often difficult to avoid 'set' expressions and poses. Fig. 54 shows a suitable arrangement to use.

Except for profiles, do not take the portrait from too close or you will produce unpleasant distortion of the features which are all too apparent in many amateur portraits. It is better by far not to come any closer than two or three yards. If at this distance the image is rather small it is always possible to enlarge it (those with a suitable camera should use a longer focal length lens, even a telephoto, and may care to experiment with old portrait lenses which are provided with controllable diffusion). Portrait attachments and close-up lenses are responsible for many horrible distortions when used without discrimination.

Try to have a uniform background behind the subject, e.g. a large sheet of wrapping paper *uncreased* of course, or a grey distempered wall, but glossy painted walls often give unpleasant 'hot spots'. An old sheet or plain tablecloth can also be used if ironed smooth. Try to use a reflector: a light-coloured wall, a white cloth, a sheet of drawing paper pinned to a wooden frame, a sheet of glass or plastic covered with silver paper, or in an emergency a clean cloth or a newspaper.

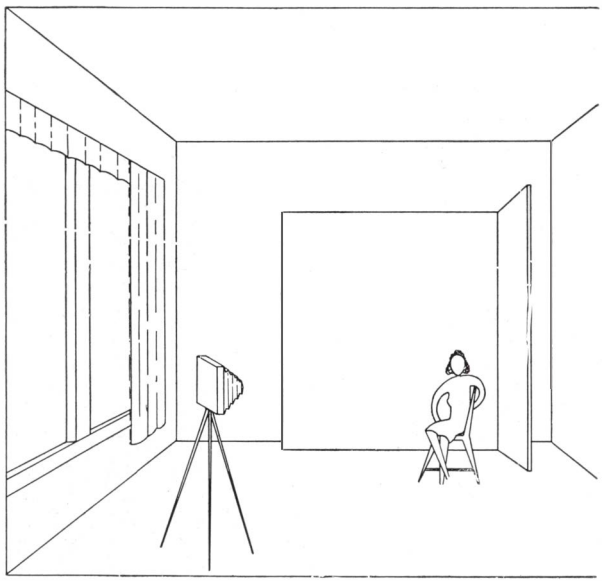


Fig. 54 On the left the window throws light on to one side of the subject (main light). On the right the screen reflects the daylight on the subject (fill-in light). Behind the subject is an even-toned background. The camera is placed to one side of the window. The subject is not pushed up against the background but placed some distance from it. The position of the screen should be adjusted to ensure that the shadows are adequately illuminated.

Finally do not as a general rule stop down and focus carefully on the eyes. Outdoors a background of leaves or a brick wall are rarely satisfactory unless they can be thrown completely out of focus.

In taking children do not try to work at your normal height unless you want to create an unpleasant perspective: over-large heads and shortened legs. Lift them up on to something or get down on the floor to take their photographs. People who 'pose' for the camera generally look unnatural. Try if you can to photograph them at their work or when their attention is otherwise distracted.

Photo: E. A. Heiniger →

The photograph should be taken unawares or as nearly as possible when they have more or less forgotten about the photographer altogether. The whole art of portraiture is psychological not technical. It comprises establishing such relations with the subject and his surroundings that he can be himself at ease with the camera and photographer. The portrait photographer needs at one and the same time a dominant and retiring personality.

Animal photography

The increasing interest being taken in the country and nature has the natural consequence that amateurs are turning more and more to photographing animals.

Experts on animals, zoologists and breeders are increasingly resorting to photography to meet the needs of their work.

This type of picture needs infinite patience, careful painstaking observation and considerable knowledge of animal ways and behaviour.

This is also the case for the photographer who wants to photograph wild animals in their natural surroundings. He must first study them for a long time to find out their habits; then and only then does he know where and how to



set up his camera. Sometimes he will have to spend hours, even a whole day, posted in a camouflaged 'hide'. Some animals, however, are suspicious despite the 'hide' and then he will have to use a telephoto lens, or better still put just his camera close to their nest or lair.

The camera is often fitted with some form of release so that the animals themselves trigger the shutter and if necessary a flash also.

All this is almost a complete science in itself which is only learned slowly and after considerable experience.

Domestic pets should not be neglected and they are much easier propositions. Dogs give particularly good expressions because they are not scared by the camera. Cats, on the other hand, need to be coaxed or tricked into 'posing' but no one who is fond of them will be deterred by so small a matter. Be careful to get them into characteristic positions. Every animal has its own personality which finds expression in a characteristic way of walking or reclining, and this is exactly what we ought to be interested in and want to set about capturing.

Groups

The whole difficulty in group photography is how to arrange the participants in an interesting, varied and natural manner. Nothing is more ridiculous than

Photo: Jorge Friedman



a group, as one often sees, with everyone arranged in a long straight row and all looking straight at the camera. Try to get them to take up easy unrestrained attitudes and if, as is very probable, this means that they are not all in a line then it will be necessary to stoop down somewhat to gain sufficient depth of field.

Lastly, avoid long exposure times and the inevitable blurring that will result. The amateur should take his groups outdoors if he can. For indoor groups use fast panchromatic films and over-volted lamps, or use flash, having first stopped down to give sufficient depth of field.

Still life

To be strictly truthful it is with still life that anyone who wants to learn to be a photographer should begin. The very nature of the subject allows every one of its elements to be arranged to the best effect. There is plenty of time to look for the most satisfactory grouping and presentation and to discover the best way to light it. A camera with a ground glass screen on which the composition can be studied as it is built up will be found very useful.

You should pay particular attention to the following points: the beginner has a tendency to overcrowd. The best way is to play around with only a minimum number of subjects (say two or three) and to select a quiet even background.

Photo : Em. Sougez



Concentrate all your attention on showing the *nature* of the objects properly: glass for instance ought to look like glass, metal like metal, and the delicate skin of a peach ought to be easily distinguished from the skin of any other fruit. In the same way tonal values of the image should correspond faithfully to the values of the subjects before the camera. To secure such a result requires careful control of the lighting, and the use of a panchromatic material such as 'Gevapan 27' plates or films. If necessary a colour filter can be used in front of the lens, a yellow or light green filter if tungsten lighting is used.

Serial photographs

It is difficult to present in a single picture the essence of an action which of its very nature takes place in a number of distinct phases. The picture magazine photographer has in similar cases demonstrated the way to do this. Instead of a single picture he takes many – each of which reveals one facet or one phase of the event in question. Then he selects and arranges a series of pictures so that they make a homogeneous whole. More often than not it is possible to succeed in arousing in this way an impression which, since it is addressed directly to the mind, retains its effect longer than a detailed description. Modern man in any case is becoming more and more accustomed to learning from pictures than from the written or spoken word. On this fact is based the popularity of the weekly illustrated papers, which satisfy this need. The written word is giving way more and more before photographic journalism in which every kind of contribution is basically composed of a related series of well-chosen photographs. World affairs are followed, one learns to tie 'one's tie', to prepare a meal or to bind a book by following a series of photographs. Very often the author intervenes only to add a few words of introduction or of explanation to carry the reader on to the next picture. Editing captions has become a profession in itself in a number of countries. And this is nearly as true for books as it is for periodicals. The market is literally swamped with photographic picture books in which the text plays only a secondary rôle and in the extreme cases has no part at all. We recall to mind for example that in the book *Factories*, by the famous Swiss photographer Tuggener, besides the title and the names of the author and editor there are hardly more than a dozen words of text. Another in Bill Brandt's *Camera in London*. The young and ambitious photographer who wants to make a name for himself in this fruitful field will find it difficult during his apprenticeship to choose between many eminent practitioners of this art.

But the amateur too will find here an inexhaustible source of pleasure and delight. Why shouldn't he try to capture in a pleasant series of connected photographs his everyday family life, his trips and his holidays. He must simply know how to organize things a little so that events take the course he wants them to. Without this modest arrangement he will not be able to procure a series which hangs together nicely. It is best to know what one wants to do and to prepare a plan, and when the series is completed it will not be found too difficult to make up a suitable text for those who have yet to learn the habit of reading pictures.

Photos: Nico Zomer →







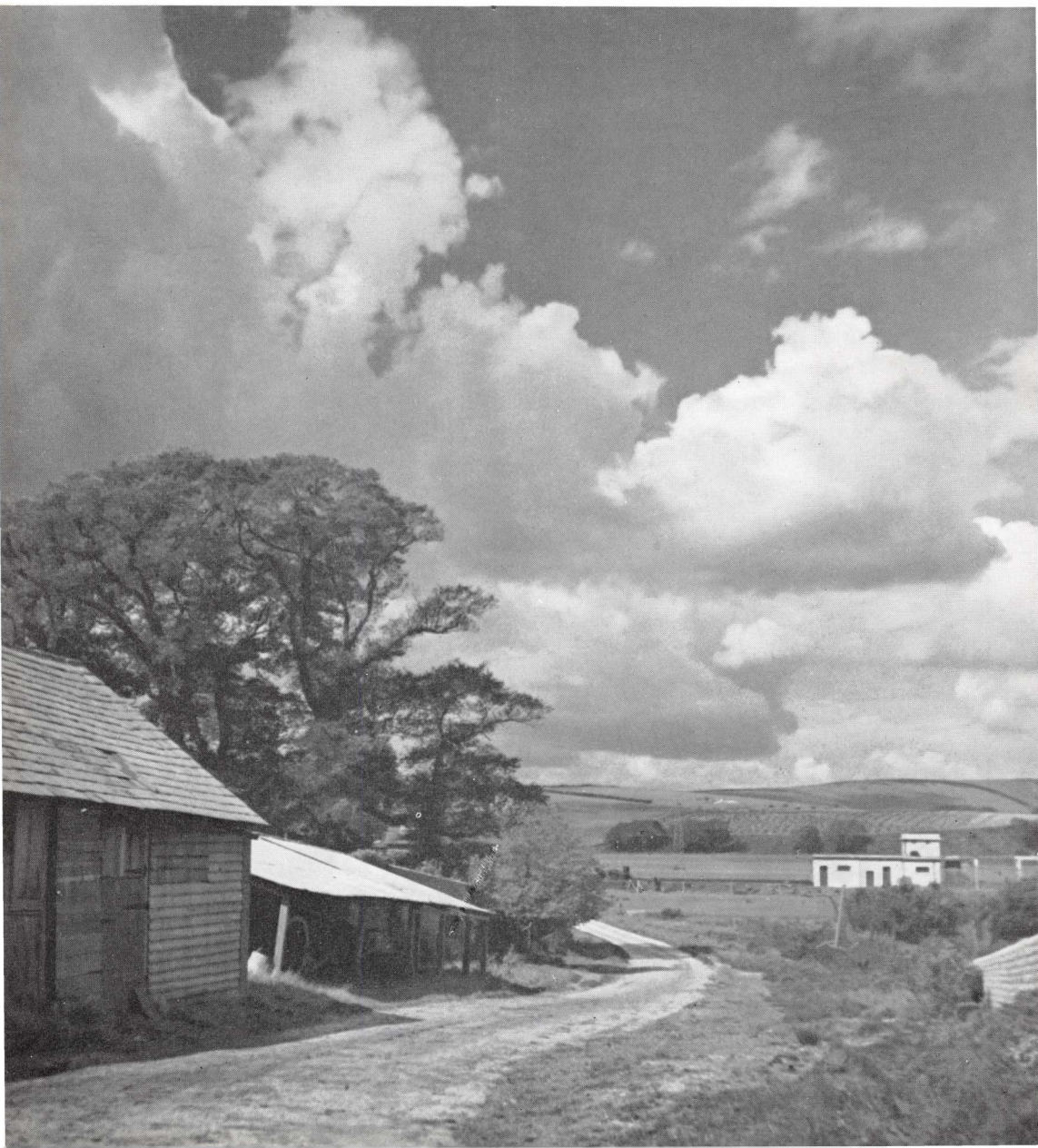


COLOUR FILTERS

With our eyes we see not only the range of tone between shadows and highlights but colours also. These differ in value and brightness. Yellow-green seems brighter than blue or violet; between these two extremes are green and red.

In other words the eye is most sensitive to yellow, less sensitive to green and red, and sensitive least of all to blue and violet.

Because of this a photograph cannot generally give us a completely satisfactory reproduction unless the relative brightnesses of the various colours correspond more or less to the way they actually appeared to the eye. Now an



ordinary unsensitized silver bromide emulsion is much more sensitive to blue and violet light than to any other colour. A photograph made with such an emulsion will have in the print light areas corresponding to the blue and violet, whereas the yellow, the green and particularly anything red, will be rendered very dark, even black. Such an emulsion went under the name of 'Ordinary', but is more often nowadays called 'blue-sensitive'. By using sensitizing dyes the manufacturer is able to make his emulsions more sensitive to yellow and green light (*orthochromatic* emulsions) and to red (*panchromatic* emulsions) and even to infra-red (*infra-red* emulsions).

When the predominant colour of a scene is blue, e.g. a landscape with sky and high sun, a yellow filter is needed. This corrects for the inherent strong blue sensitivity of the material and holds it back to a correct value as compared with the sensitivity to yellow.

What filter should be used?

The choice depends on the sensitivity of the emulsion to different colours, the colour balance (spectral composition) of the light and the effect desired. Filters can be divided into three groups.

A. Compensating filters.

B. Contrast filters.

C. Three-colour separation filters.

A. Compensating filters are intended to reduce the effect of certain spectral radiations (colours) without absorbing them completely. Light and medium yellow filters fall into this category. They reduce the action of blue light. The effect is more pronounced the deeper the colour of the filter.

B. Contrast filters absorb certain colours (radiations) completely and are therefore mainly used to suppress or accentuate certain colours in the subject. Some of them are in fact very deeply coloured compensating filters, e.g. a dark yellow or orange filter (which absorbs practically *all* the blue). In practice their use is limited to reproductions of paintings, drawings, etc., particularly hand-coloured work, watercolours, etc., although some are of particular use with furniture and polished woods and the like.

C. The third group comprises those filters which split up white light into three coloured primaries, blue, yellow and red. They are used in the graphic arts – printing – to make colour separations for three and four-colour printing.

When using filters the following two things need to be taken into account:

(*a*) Any loss of sharpness they may cause;

(*b*) The increase of exposure they require.

(*a*) The lens makers have corrected their lens to be free from aberrations so that they should give perfectly sharp images. Putting a piece of glass or gelatine in front of the best lens will degrade the image a little. Happily this loss will remain unnoticed except in the highest enlargements. The least loss occurs with 'dyed in the mass' glass filters, provided they are accurately ground flat and

← *A Sussex Lane – Photo: Colin J. Unsworth*

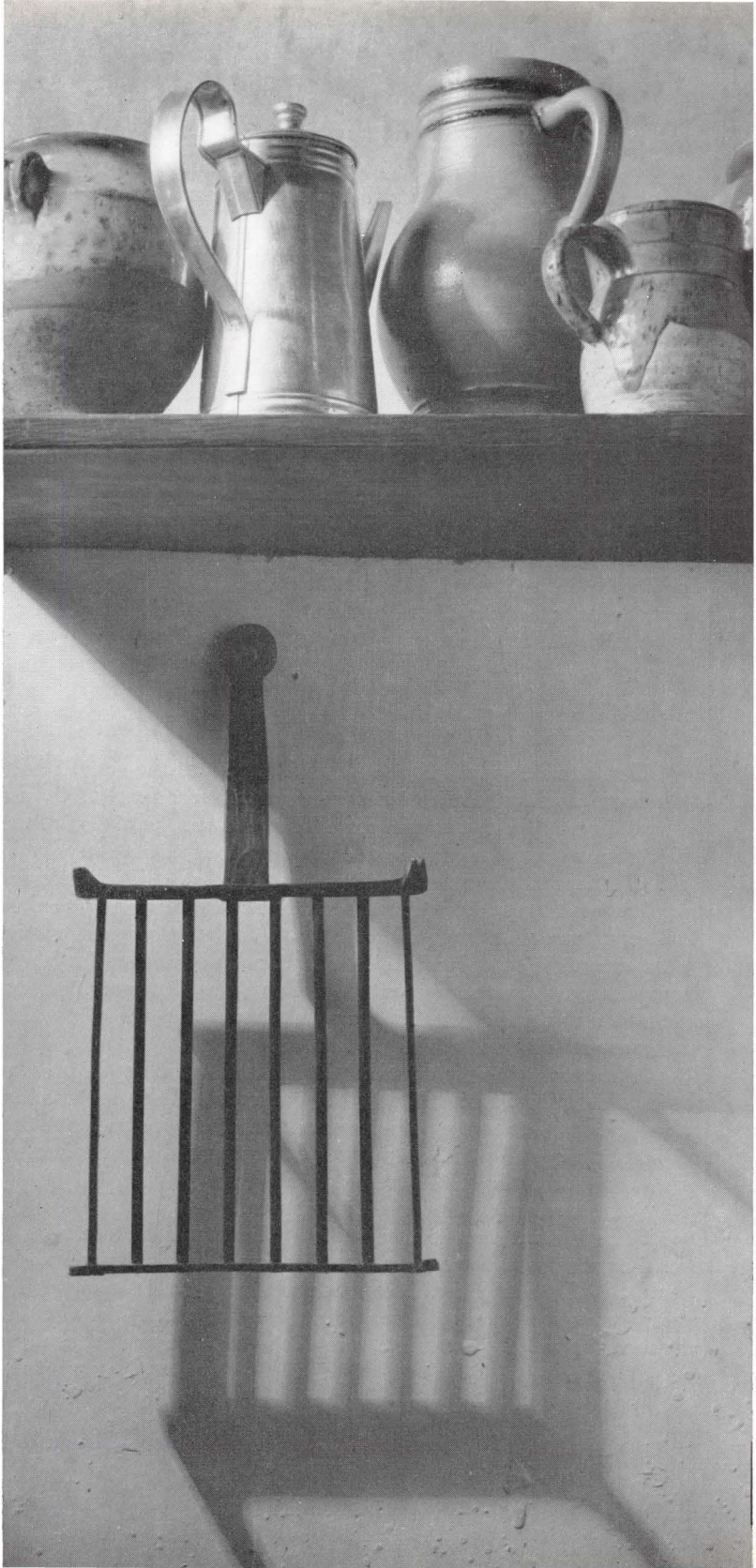


Photo : Em. Sougez

parallel to the same close limits as the lens. These should, therefore, be used with miniature cameras, since in this case the negatives are usually considerably enlarged.

(*b*) The filter absorbs certain radiations so that a greater exposure is needed.

The makers frequently mark on the filters the filter factor by which the exposure time *without filter* should be multiplied for the same development and for the same negative quality.

This factor is by no means invariable, and changes according to the colour sensitivity of the emulsion in use. For this reason the makers include in their instructions for the use of the filters the factors to be used with most commonly available makes of films and plates.

Haze (U.V.) filters should be used when photographs are made at heights above 6,000 ft., climbing or mountaineering, or in exceptionally dry or clear air near or over the sea. These absorb the ultra-violet radiation to which all emulsions are very sensitive and which are much more abundant above this altitude. Even though such filters have a light yellow or straw colour the exposure should not be increased. It is not advisable to use ordinary yellow filters above 6,000 ft. The colouring agent used in their manufacture fluoresces under the action of the U.V. and they therefore give an overall fog with consequent loss of sharpness.

Some practical instructions for using filters

General rules as to the use of filters are difficult to formulate. Each case must be considered on its merits according to the effect envisaged. The same subject can be taken perhaps without a filter, or then again with a light or a dark filter according to the lighting conditions, the time of year, the hour of the day and the result required.

For example: the countryside under snow can be taken in the morning or near evening without a filter or with only a light filter by using good orthochromatic or panchromatic plates or films such as Gevaert materials.

At midday, however, a light or medium filter should be used. When it is desired to reproduce clearly all detail at a considerable distance a medium or dark filter is essential. In such cases it is true we shall sacrifice the atmospheric effect of softness in the distance. A gain in clarity is offset by a loss of artistic effect, so that the impression of great distance is lost. The same applies to a misty landscape. A light yellow filter is appropriate in this case because the mist reflects mostly blue light and as a consequence the subject before the camera is one in which blue predominates. The pleasant effect produced by the mist can be absolutely destroyed by the use of a dark filter. These two examples are sufficient to demonstrate that blue absorbing filters need to be used judiciously and with discrimination when they are employed to overcome the normally disproportionate effect of blue light. Do not use them unnecessarily. In doubtful cases it is far better to abstain from using a yellow filter, more especially since the high degree of green, yellow and red sensitivity of Gevaert orthochromatic



Kerima in 'Outcast of the Islands' *Photo: Leslie H. Baker*

and panchromatic films and plates is ample guarantee of a satisfactory colour rendering even when no filter is used.

There are occasions, however, when, for special purposes, the exaggerated effect (over-correction) caused by the use of heavy filtering is desired. The menace of a stormy sky can be very much accentuated in this way by the use of a medium filter and a normal sky with plenty of clouds can be changed into a stormy sky by the use of a contrast filter.

Red filters can be used to give pictures taken in daylight the effect of night shots. A red filter cuts out the blue and green. The sky and countryside, therefore, come out dark, almost black in the print leaving only the strongly sunlit specular highlights (houses, water, etc.) reproduced as white or in light tones. This gives a curious moonlight effect. Red filters obviously can only be used with panchromatic materials since other kinds of plates and films are not sensitive to red radiation. In America infra-red filters and films are frequently used for shooting moonlight effects. The chlorophyll of green leaves reflects some infra-red rays and this gives the foliage a pleasant shimmering effect. Otherwise the result is rather similar to the effect produced by a red filter and panchromatic film.

As a general rule green filters are only used to reduce the effect of red radiation (especially in artificial light) on panchromatic films and plates which are rather too sensitive to red, as this then results in a better rendering especially of skin, lips, etc. As far as this is concerned it should be noted that 'Gevapan' material renders reds in their correct tone without the use of any correction filter.

'Geva' filters

Gevaert supply colour filters under the trade name 'Geva' filters. They can be obtained:

(*a*) In gelatine sheet form;

(*b*) Gelatine cemented between two sheets of polished glass.

They are divided into three groups, each with different characteristics. Yellow filters, filters of other colours, and neutral density filters.

Note: Never use any of these filters for colour photography. They produce a colour cast of the same colour as that of the filter used. Gevaert supplies 'Gevacolor CT' filters for use in colour photography.

★ Handling

Gelatine film filters should be handled with extreme care, and held only by the edges. They should be kept in the baryta paper they are packed in and placed in a box or between the leaves of a book to protect them from damp, dust and heat.

Moist finger-prints and similar markings cannot be removed. Loose dust can be removed with a soft brush, which must be very clean and dry. The filters can be cut with scissors by holding them between the two sheets of paper and cutting both papers and filter together.

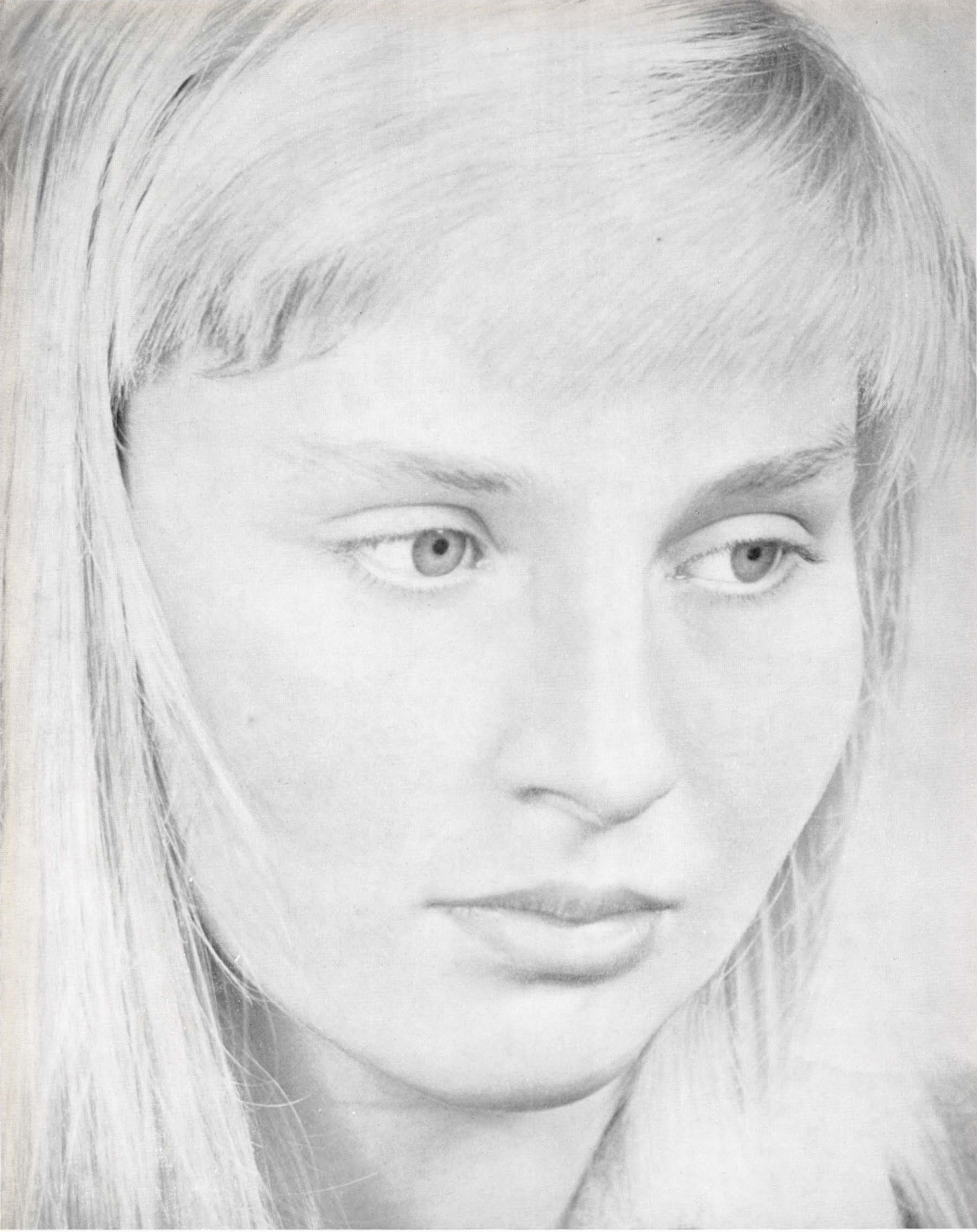


Photo : Gertrude Ferh

★ Types available

1 – Yellow Filters

Yellow filters are arranged in order of density, the depth of the filter increasing with the number. Yellow filters are used with orthochromatic or panchromatic materials, the deeper ones principally with the latter. A few typical effects are mentioned below.

No.	*Colour*	*Remarks*
2	Yellow	Moderate correction filter.
3	Yellow	Absorbs ultra-violet and part of the blue. Standard correcting filter for photographing distant objects, architecture, beach scenes, mountain scenery and snow scenes.
5	Yellow	Absorbs the ultra-violet and practically all the blue. A contrast filter for overcorrecting the blue. The sky then appears distinctly darker than in reality. The haze in the distance is greatly reduced.

2 – Filters of other colours

This category comprises in particular those contrast filters which can be used for lightening and showing more detail (on the print) in any subject of colour approximately that of the filter. Subjects of a more or less complementary colour to the filter are rendered darker. In the absence of remarks to the contrary, these filters are to be used solely with panchromatic material.

No.	*Colour*	*Remarks*
R578	Orange	Green, and especially blue objects, appear darker.
R599	Red	Absorbs ultra-violet, blue and green. A filter with strong contrast. The blue and green parts of the subject appear very dark, while the yellow, orange and red parts appear very light. Gives a dramatic appearance to landscapes which have a blue sky as background.
R628	Dark red	Stronger than R599. Absorbs ultra-violet, blue, green and yellow-green.
G525	Green	Absorbs ultra-violet, blue and red. Makes blue and red appear dark, while yellow or green subjects are rendered very light.
B488	Blue	Gives orthochromatic or panchromatic plates and films almost the same colour rendering as a non-chromatic emulsion.
R719	Infra-red	Absorbs all visible light. Is used only with infra-red films or plates.

★ Absorption curves of the filters

From the absorption curves, it is possible to see at a glance what part of the light is absorbed by the filters (black parts of the curves) and what part is transmitted. Remember white light may be split up into a number of radiations of different wavelengths with the following range of colours:

The figures on the scale indicate the wavelengths of the light, expressed in millimicrons ($m\mu$), i.e. in millionths of a millimetre.

Pure spectral colours are seldom found in nature but generally mixtures of pure colours. The

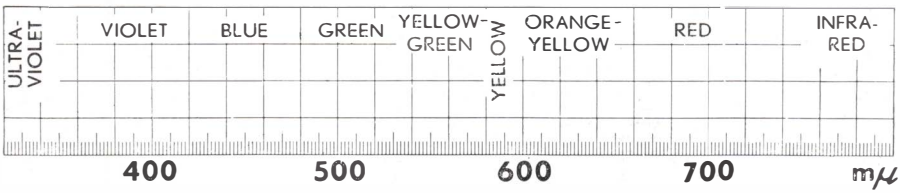


Fig. 55

yellow that one usually sees, for example, is a mixture of green and red. A yellow filter (see fig. 55) must, therefore, transmit freely radiations of about 500 $m\mu$ and above, while absorbing more and more radiations having wavelengths shorter than 500 $m\mu$ as its depth increases.

In the diagrams given below, the upright scale on the left-hand side represents the transparency or degree of transmission, i.e. the percentage of light penetrating through the filter. This scale is logarithmic and may be subdivided as shown in fig. 56a. The right-hand upright scale gives the same information in another form, the density scale which simplifies reading. It

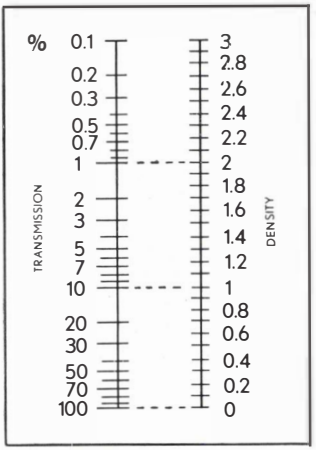


Fig. 56a

DENSITY	OPACITY	TRANSMISSION
0	1	100 %
0.2	1.6	63 %
0.4	2.5	40 %
0.6	4	25 %
0.8	6.3	16 %
1	10	10 %
1.2	16	6.3 %
1.4	25	4 %
1.6	40	2.5 %
1.8	63	1.6 %
2	100	1 %
2.2	160	0.63 %
2.4	250	0.4 %
2.6	400	0.25 %
2.8	630	0.16 %
3	1000	0.1 %

Fig. 56b

shows the density – which is the logarithm of the opacity of the filter. Table fig. 56b shows the relations between these different quantities.

See for example, the curve of fig. 57. When the filter represented by the curve is used the dotted lines show that:

(1) Radiations of a wavelength shorter than 500 $m\mu$ are totally absorbed (density higher than 3·0, i.e. transmission below 0·1%).
(2) At 520 $m\mu$ the density has dropped to 1·8 (a transmission of 1·6% according to the table).
(3) At 550 $m\mu$ the density is 0·4 (transmission 40%).

Such a filter absorbs practically all the violet and blue, and reduces the green to some extent, while allowing the yellow-green, yellow-orange and red to pass almost freely. (See fig. 55 for relationship between wavelength and colour.)

The filter nomenclature and the principal absorption curves are given in the following pages. The curves are set out in alphabetical and numerical order.

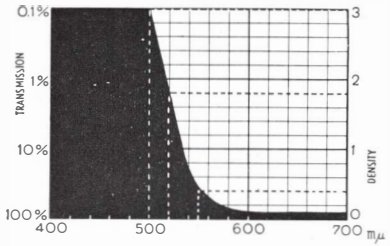


Fig. 57 Absorption curve of a filter

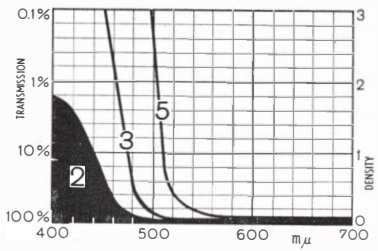
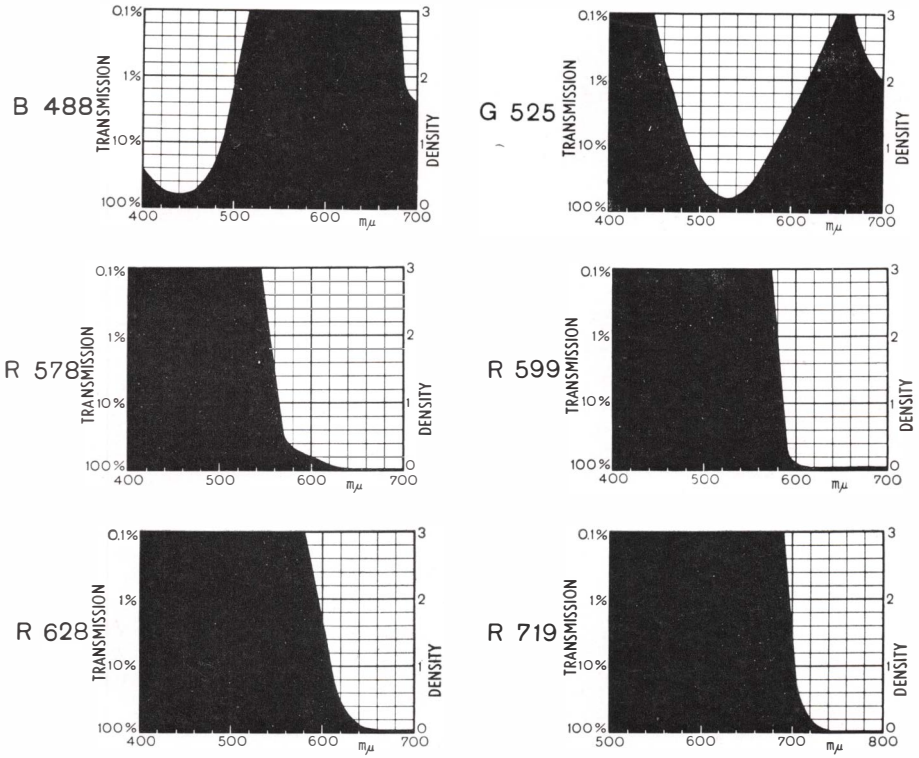


Fig. 58 Yellow filters

Curves for yellow filters are shown in one diagram in fig. 58, so that rapid comparisons of their effects can be made. (In this illustration that part of the spectrum absorbed by filter 2 has been blacked out, while for filters 3 and 5 the part absorbed is to the left of the curve.



Note: Absorption curves for other Gevaert filters (for the graphic arts, colour photography, etc.) are available on request. In addition to filters for black-and-white and colour photography, Gevaert also supply a complete range of filters for darkroom safelights, for studio lighting and for colour printing and enlarging on paper.

Factors for 'Geva' gelatine filters

Filters absorb a part of the light which falls upon them and they, therefore, need an increase in exposure. This increase depends not only on the filter used but on the colour sensitivity of the photographic materials used, on the colour of lighting and on the reflectivity of the subject. The increase required is usually given in the form of a 'filter factor', applicable to the average subject, for a given class of sensitized materials either in daylight or in artificial light (at 3,400°K.).

The exposure given can be increased in two ways, by:

(*a*) using a lower shutter speed;

(*b*) using a larger lens stop.

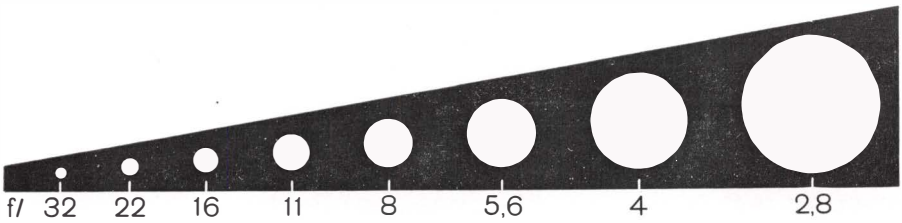


Fig. 59

Example: A particular photograph requires, with no filter, an exposure of 1/100th second at *f*/11. If a filter with a filter factor of 4x is used, any one of the following may be used:

(*a*) *f*/11 and 1/25th second (reduction of shutter speed to $\frac{1}{4}$ of the original).

(*b*) *f*/5·6 and 1/100th second (opening the aperture by two stops).

(*c*) *f*/8 and 1/50th second (combination of the two methods, viz: halving the shutter speed and increasing the aperture by one stop).

Remember each time the aperture is opened by one stop in the series shown in fig. 59 the amount of light entering the camera is doubled.

For example, opening the stop from *f*/16 to *f*/5·6 – an increase of three stops



in the aperture, the amount of light passing through the lens is multiplied by $2 \times 2 \times 2 = 8$.

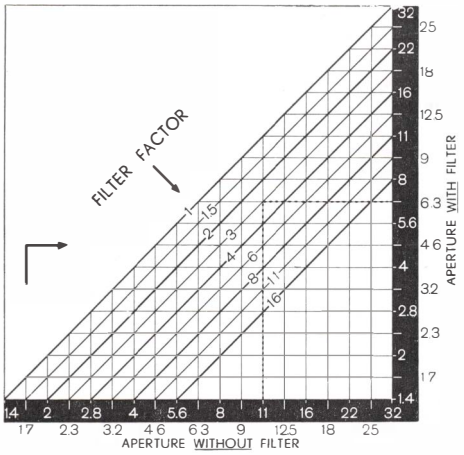


Fig. 60

The diagram opposite (fig. 60) shows how the aperture of the diaphragm should be changed according to the filter factor, when the shutter speed and other conditions remain unchanged. The dotted line shows, for example, that an aperture of 11, without filter, corresponds to an aperture of 6·3 (or halfway between 5·6 and 8) when using a filter with a factor of 3. The filter factors applicable to each group of sensitization are then substantially constant for the illumination conditions given. This diagram is particularly useful for cinematography. To use the diagram follow a vertical line from the stop used *without* filter until the 45° line corresponding to the filter factor in use is met. At this point move horizontally to the right to intersect the right-hand scale in the corresponding stop for use *with* filter. It is worth noting that an exposure factor of 1 indicates that the exposure with filter is identical with that without filter.

The different varieties of Gevaert plates and films have been classified as follows, according to their colour sensitivity:

Group I	Roll and/or miniature film	'Gevapan 27' 'Gevapan 30' 'Gevapan 33' 'Gevapan 36'
	Studio film (cut or sheet film)	'Gevapan 30' 'Gevapan 33' 'Gevapan 36'
	Plates	'Gevapan 30' 'Gevapan 33' 'Gevapan 36'
Group II	Reversal miniature film	'Dia-Direct 26 Pan Reversal'
Group III	Studio film Plate	'Gevachrome 32' 'Gevachrome 32'

← *Photo: Philip Johnson*

The filter factors for these different groups are given in the Table below:

(D=Daylight. T=Tungsten (artificial) light))

Colour	*No.*	1		2		3	
		D	*T*	*D*	*T*	*D*	*T*
Yellow	2	2	1·5	2	1·5	2·5	1·5
Yellow	3	2	2	2·5	2	3·5	2
Yellow	5	3	2·5	3	2	6	3
Orange	R578	4	3	5	3·5	—	15
Red	R599	6	5·5	10	10	—	—
Red	R628	12	10	—	—	—	—
Green	G525	10	10	8	7·5	11	7
Blue	B488	10	—	8	—	8	—

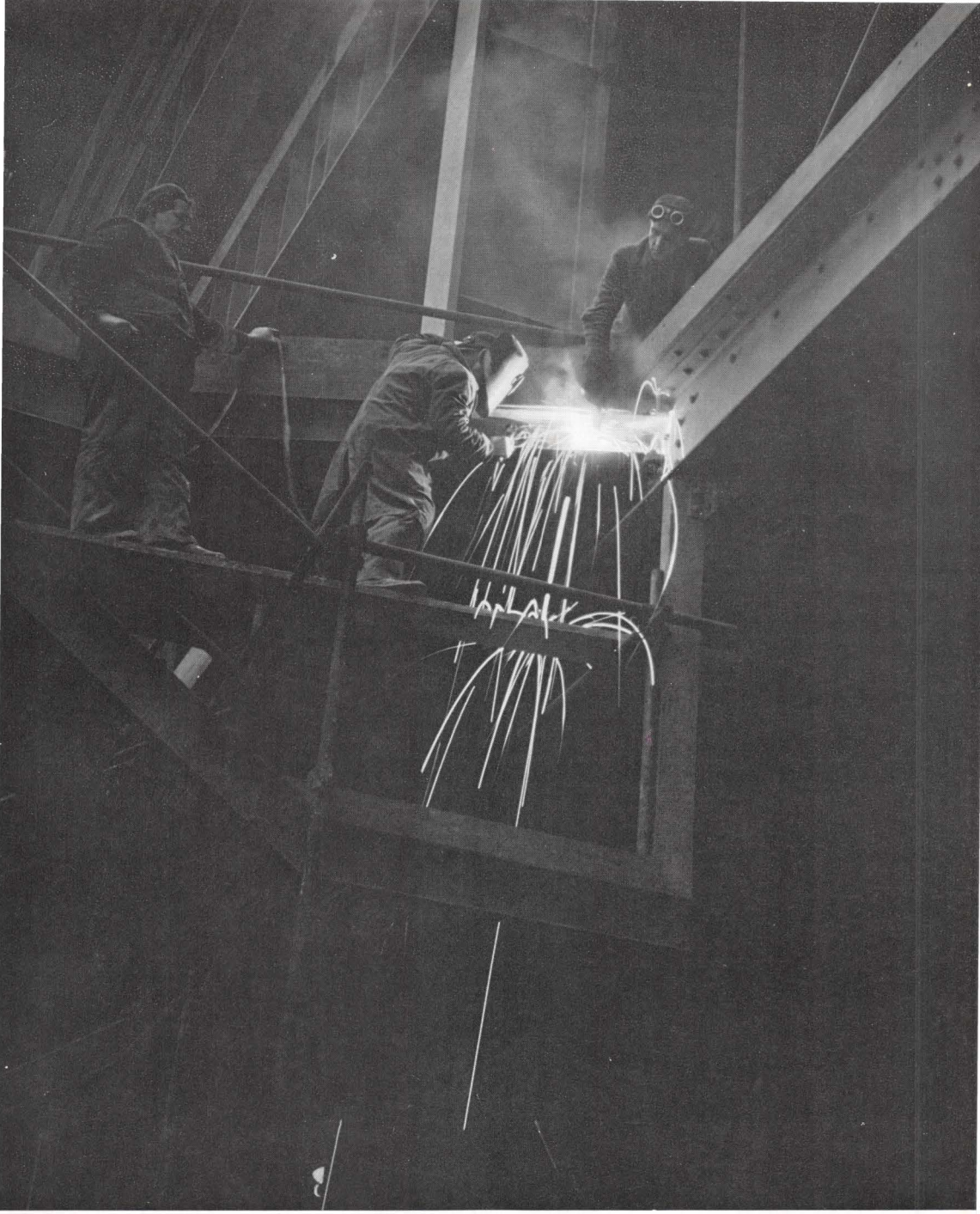


Photo : Richard Gee



Photo : R. Kourken

THE NEGATIVE MATERIAL

The negative is the basic element in all photography. A negative material of the necessary characteristics and which can be relied on is therefore absolutely essential. The actual choice of material is a personal matter: you can use roll film, miniature film, flat film or plates.

Amateurs, especially when on tour, generally prefer roll film or miniature film. Professionals on the other hand predominantly use flat film or plates. The final choice is made very much easier because whatever the type of work, portraiture, paintings, landscape, copying, etc., Gevaert market a wide variety of plates and films suitable for each specific task.

Why have different kinds of films and plates?

When a choice is to be made and one examines the assortment of films and plates listed it is tempting to ask why there are so many different kinds. The answer is simple.

There are many diverse applications of photography. A film or plate that is quite suitable for one particular case cannot be used for another job where conditions are entirely different.

As a consequence for studio work, the portrait photographer uses quite a different sort of film or plate to the press photographer whose work is to be used solely for reproduction in newspapers and periodicals and so on.

Each branch of photography requires a negative material with different characteristics.

The portrait photographer wants to get a faithful and at the same time pleasing likeness. So he prefers a soft working emulsion which gives good tone separation with maximum detail in the shadows as well as in the highlights. These qualities are of the greatest importance in the negative material to be used for 'contre-jour' (against-the-light – 'halo' effects) which are much sought after in modern portraiture. Without them very contrasty results will be procured. The photographer, moreover, must have available a very fast material when he has to take nervous sitters, children, and large groups. As for the pressman – his job is to produce adequately exposed sharp pictures at all times, no matter how bad the lighting conditions may be. That is why he likes a high speed plate with plenty of contrast. He also likes it to develop and fix rapidly, and generally chooses plates because these are easier to print wet. Nowadays it is possible to produce an enlargement within $1\frac{1}{2}$–$2\frac{1}{2}$ minutes of taking the photograph without much special equipment or elaborate solutions.

The amateur wants films and plates which are fairly universal and can be used for a variety of subjects (portraiture, landscape, sports photography, etc.) without the necessity of continually having to change his material. He accordingly chooses a material with adequate speed, of fair contrast, which has a wide exposure latitude, and one which can if desired be developed to either a fairly low or a fairly high contrast. For work indoors by natural or artificial light he will have to use the fastest speed material he can find, preferably panchromatic.

Amateurs or scientists who are interested in the scientific applications of photography – such as photomicrography – need a special series of sensitive materials which are intended specifically for the type of work they wish to engage in.

From all this it can be seen that to each type of photographer and to each application correspond special types of films or plates. The correct choice is half the art of good negative making, and to this end the manufacturer consequently devotes much attention and published advice.

There are, of course, a number of features which all desire. Fineness of grain is one, especially for miniature work and for negatives that are going to be 'blown up' to large sizes. Here the demands are quite severe, and require special 'fine grain' emulsions.

For certain types of work the paramount necessity is to reproduce colours with correct relative brightnesses. In such cases panchromatic material must be used.

The information on Gevaert materials which is tabulated below shows that all these possible uses have been catered for adequately so that every category of photographer can find material to suit his needs. These materials are only those which are suitable for what we shall call 'general photography'.

Gevaert can also supply a complete range of sensitive materials for every kind of 'special' photography. For instance, there are 'Graphic' films and plates for use in the photomechanical processes by which blocks and plates for printing are prepared.

'X-ray' materials are another sort of special sensitive materials. These are used extensively in industry as well as in medicine.

'Scientific' films and plates are specially adapted, for the various techniques used in scientific research, such as metallography, spectrography, oscillography, etc.

A description of these techniques is obviously outside the scope of this book. We shall confine ourselves to a discussion of Gevaert materials for normal types of photography.

GEVAERT ROLL FILMS AND MINIATURE FILMS

'Gevapan 27'

'Gevapan 27' is a medium speed panchromatic film with *ultra-fine grain*, specially recommended in all cases where negatives are intended to be considerably

The Painter John Piper – Photo: Hugo van Wadenoyen →

enlarged. For outdoor photography and all cases where high speed is not essential. Excellent rendering of tonal values of all colours. Great exposure latitude.
Resolving power: 125 lines/mm. (3,200 lines/inch)

Recommended meter settings:

17 *DIN* 40 *ASA* 3·5°

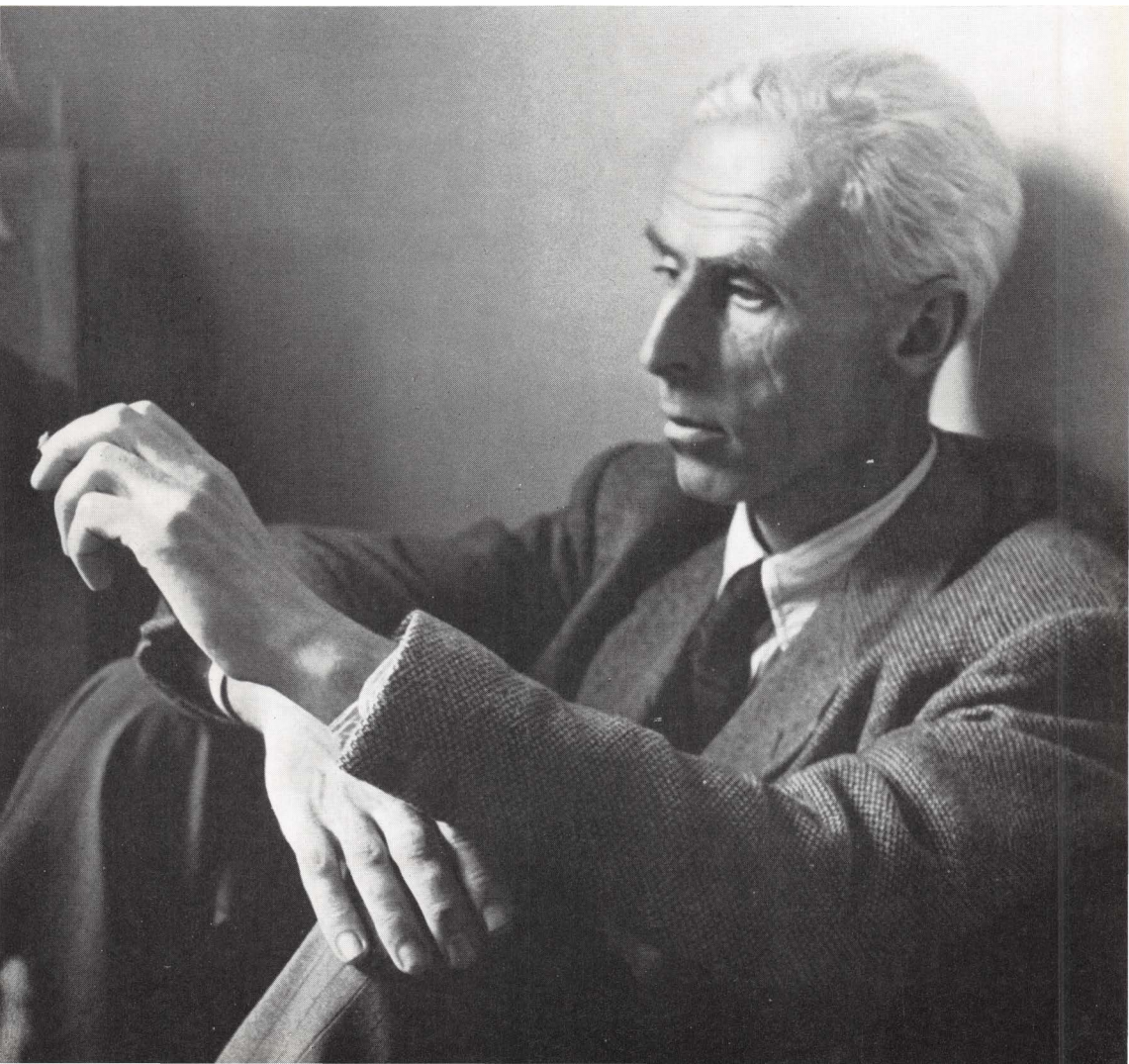
'Gevapan 30'

'Gevapan 30' is a panchromatic film of *high speed* and *fine grain* for general use. It yields pictures of brilliant gradation and a wealth of detail and an excellent rendering of the relative tonal values of all colours. Great exposure latitude.

Resolving power: Roll film: 110 lines/mm. (2,800 lines/inch)
Miniature film: 115 lines/mm. (2,900 lines/inch)

Recommended meter settings:

22 *DIN* 125 *ASA* 5°



'Gevapan 33'

'Gevapan 33' is a high-speed panchromatic film of full gradation for indoor photography, both by artificial light (tungsten and flash) or in daylight. It is specially suitable for outdoor photography under unfavourable lighting conditions, such as photography with high shutter speeds (fast moving subjects). Considering the high speed of this film the grain remains surprisingly fine. Great exposure latitude.

Resolving power: Roll film: 95 lines/mm. (2,400 lines/inch)
Miniature film: 100 lines/mm. (2,550 lines/inch)

Recommended meter settings:

25 *DIN* 250 *ASA* 6°

'Gevapan 36'

'Gevapan 36' is an ultra-high-speed panchromatic film, particularly recommended for use under poor lighting conditions where flash would normally be used. Has a gradation capable of recording a long scale of tones and capable of being subjected, if necessary, to forced development to give maximum speed. Great exposure latitude. Fine grained for such a fast material.

Resolving power: Roll film: 90 lines/mm. (2,300 lines/inch)
Miniature film: 95 lines/mm. (2,400 lines/inch)

Recommended meter settings:

27 *DIN* 400 *ASA* 7°

Sizes and loadings of Gevaert roll films, etc.

★ Roll films

In all normal sizes on spools with both small and large centres – 620 and 120 sizes, 127.

★ Miniature films (35 mm.)

(*a*) Daylight loading:
Cassettes: 20 exposure and 36 exposure.
Reloads: 36 exposure.

(*b*) Darkroom loading.
Reloads: 36 exposure.
Spooled lengths of 10 × 36 exposures.

GEVAERT SHEET FILMS

All Gevaert sheet films are provided with a very efficient anti-halation layer. They are easy to retouch and can be obtained with the non-emulsion side of the base clear or matted. They are very suitable for portraiture, for advertising photography, for commercial and industrial photography and for press work.

'Gevachrome 32'

Very high-speed orthochromatic sheet film, of brilliant gradation and fine grain. The universal ortho film, particularly suitable for artificial light subjects, por-

traiture, press and commercial photography. It is equally useful with very contrasty subjects. Effective anti-halation backing. Very easy to retouch.
Resolving power: 90 lines/mm. (2,300 lines/inch).

Recommended meter settings:

Daylight:	22 *DIN*	125 *ASA*	5·5°
Artificial light:	19 *DIN*	64 *ASA*	4·5°

'Gevapan 30'

High-speed panchromatic sheet film, of brilliant gradation and fine grain, for all subjects in artificial light and daylight. Very easy to retouch. Effective anti-halation backing.

Resolving power: 90 lines/mm. (2,300 lines/inch).
Recommended meter settings:

22 *DIN*	125 *ASA*	5°

'Gevapan 33'

Extremely fast panchromatic sheet film, specially suitable for subject, of high contrast, in artificial light, and in very poor light. Press, sports and studio photography. Yields soft gradation and fine grain even at this extreme emulsion speed. Very easy to retouch. Specially effective anti-halation backing.

Resolving power: 90 lines/mm. (2,300 lines/inch).
Recommended meter settings:

25 *DIN*	250 *ASA*	6°

'Gevapan 36'

A panchromatic sheet film of extremely high speed and rich gradation, especially useful for press photography and for exposures under poor lighting conditions. Great exposure latitude. Fine grain in view of the very high sensitivity of the emulsion. Effective anti-halation backing.

Resolving power: 90 lines/mm. (2,300 lines/inch).
Recommended meter settings:

27 *DIN*	400 *ASA*	7°

GEVAERT PLATES

'Gevachrome 32'

An orthochromatic plate of high speed for portraiture, industrial, commercial and press photography. Brilliant gradation and fine grain. Anti-halation backing.

Resolving power: 90 lines/mm. (2,300 lines/inch).
Recommended meter settings:

Daylight:	22 *DIN*	125 *ASA*	5·5°
Artificial light:	19 *DIN*	64 *ASA*	4·5°

'Gevapan 30'

A fast panchromatic plate of fine grain and perfect black and white reproduction of colours. Suitable for portraiture and photography of subjects that do not present high contrasts nor demand short exposure times. Recommended for all studio work with studio cameras as well as with repetition cameras of the multiple image type. Anti-halation backing.

Resolving power: 95 lines/mm. (2,400 lines/inch).

Recommended meter settings:

22 *DIN*	125 *ASA*	5°

'Gevapan 33'

A panchromatic plate of very high speed and relatively fine grain. The rather soft gradation of this plate yields negatives with full details in both shadows and highlights, especially of very contrasty subjects. The high speed of 'Gevapan 33' has been proved ideal for studio and press work – indeed in all circumstances where it is necessary to operate with high shutter speeds or in very poor light. Recommended for studio portraiture, and press photography both in daylight, artificial light, flash light and electronic flash.

Resolving power: 90 lines/mm. (2,300 lines/inch).

Recommended meter settings:

25 *DIN*	250 *ASA*	6°

'Gevapan 36'

A panchromatic plate of extremely high speed and rich gradation, especially useful for press photography and for exposures under poor lighting conditions. Great exposure latitude, fine grain, in view of the very high sensitivity of the emulsion. Anti-halation backing.

Resolving power: 90 lines/mm. (2,300 lines/inch).

Recommended meter settings:

27 *DIN*	400 *ASA*	7°

'Replica 23'

A slow orthochromatic plate used for copying old photographs, engravings, etc. Equally suitable for normal photography when a slow plate is required. Brilliant gradation and very fine grain. For all commercial and illustrative work whenever short exposures are not required. Anti-halation.

Resolving power: 90 lines/mm. (2,300 lines/inch).

Recommended meter settings:

Daylight:	13 *DIN*	16 *ASA*	2°
Artificial light:	10 *DIN*	8 *ASA*	1°

Photo: Derek Evans →





PROCESSING NEGATIVE MATERIALS

GENERAL

In this chapter are given only those practical rules which are strictly essential to process sensitive materials satisfactorily. If you have no inclination to probe the principles of photographic theory then only this chapter need be read. Serious workers, however, are advised to take the trouble to read through the contents of the preceding chapters. They will then be able to understand what is behind the various steps and this will not only add to the pleasure they will have from mastering photography, but will also give them more confidence when they have to decide the causes (and cures) of various faults and difficulties.

Darkroom illumination

Sensitive materials must be developed in a place from which ordinary daylight has been carefully excluded. This must be carefully checked. The slightest sliver of direct light or even a glimmer of reflected light can easily fog a film or plate.

During development and fixing the darkroom* is lit by a safelight or darkroom lamp which gives only *non-actinic* light, i.e. light which has no effect on the emulsion. A dark red light is used for orthochromatic films and plates, for panchromatic materials only a very weak indirect green light can be used.

Remember an *absolutely* non-actinic light does not exist and in fact is unnecessary. All that is required of the darkroom lighting is that it should have relatively little action on the emulsion and not cause it to fog *during the time for which the emulsion is exposed to it during development.* For instance if development takes place in a covered tank or covered dish, and this is *always* advised for super high speed materials, the green light need only be safe for the unloading, immersing and transferring times. Many workers to whom the routine is familiar prefer to work in total darkness, especially if they are developing by time and temperature under standard conditions. On the other hand the lighting must be strong enough to allow the image formation to be watched and checked when dish development, or prolonged development by inspection is being used. The strength (intensity) and the placing of the lighting that is chosen must then be a compromise between these two extremes, and as much light should be allowed as can be tolerated with prudent and methodical

* Advice on fitting up a darkroom is given in Part III.

← *Photo: H. & T. Scheerer*

working. For this reason an experienced photographer will cover the dish with a piece of dark cardboard during development so that he is able to use a stronger safelight than a colleague who does not take this precaution.

Too many people, moreover, think that development by inspection consists of taking the plate out of the developer and holding it up to the lamp at frequent intervals, and as close to the safelight as possible. The faults that will be caused by this treatment are mentioned later. It follows that under such circumstances the safelight must be very feeble if fog is to be avoided. It is reasonable to suggest that it will be much easier all round to cover the dish or tank and to wait patiently using a much brighter safelight. When developing like this you should restrict yourself to inspecting the plate only occasionally, and then as rapidly as possible and at a reasonable distance away from the lamp.

From what has been said you might deduce that a dim light is automatically safer than a strong light. This is not necessarily always so. There are red safelight lamps which, although quite dark, nevertheless allow sufficient actinic rays through to fog orthochromatic emulsions under ordinary working conditions and others which although they appear relatively bright have no observable effect on these emulsions.

★ Desensitization

Those who wish to be able to develop panchromatic plates by inspection are advised to desensitize their plates before development, by immersing them for two minutes, in total darkness, in a solution of pinacryptol green made up to the formula given on page 85.

Chemicals

Practically all amateurs and many professional photographers prefer to use prepacked chemicals in powder form which only have to be dissolved in water to give a developer or fixer which is ready for use. There are, in addition, a larger number of specially compounded liquid developers of high concentration and long shelf life which are particularly suited for amateur use and are probably more economic when used sporadically, despite their slightly higher initial cost, than those prepared from powder. A list of Gevaert prepacked chemicals is given in Part V of this book together with brief instructions for use.

Gevaert 'Refinex' developer is the best developer for amateurs. The chemicals which make up 'Refinex' are packed in two small tins, and these are dissolved in 800 c.c. of warm water at about 105°F. (40°C.). When they have completely dissolved add enough water to bring the total volume to 1 litre. This developer is sufficient for developing several roll films. It keeps well if care is taken to return it after use to a well-corked bottle. Always label bottles clearly with contents, date made up, and number of films already processed in it. As soon as it begins to turn brown it must be discarded.

'Acidofix' is a very suitable fixing bath to use. If you want to make up your own solutions then use the formulae given in the appropriate chapter (or see Part V). The abbreviation cm.^{3} or cmc. which is used throughout stands for cubic centimetres or c.c.s, i.e. the 1/1,000 part of a litre. With the aid of a

graduated measure which can be bought at any photographic dealers or laboratory suppliers, quite small quantities of solutions can be made up if so desired.

Developing and fixing solutions should be used at temperatures between 60°F. and 70°F. (16–20°C.). If they are too cold they act very slowly and will not give satisfactory results. Similarly solutions which are too warm are likely to cause the gelatine emulsion layer to frill and come away from the support.

★ 'Gevatol' – wetting agents

Many amateurs try to avoid 'air-bells' in development by pre-soaking the film in water beforehand. (This treatment can also be used to remove the alkali-soluble dye of the antihalo backing to prevent it contaminating the solution.) In recent years increasing use has been made of wetting agents such as 'Gevatol' for this purpose. The wetting agent (or surface-active agent) can be used in a water pre-bath, the concentration to be used and the time required for soaking are generally given by the suppliers.

A number of wetting agents are precipitated in alkaline solution. In such cases they cannot be used in strongly alkaline developers which would decompose the wetting agent and should be diluted with water that has been *slightly* acidified. If a film is soaked in tap water and then hung up it is easy to see that as a general rule the surface is by no means evenly wetted, the water collecting together in small drops and pools on the surface. These are kept together by the molecular cohesive forces. This effect is strongest at the liquid-air interface which behaves as if it were a kind of skin or membrane which has been given the name of surface tension. This is what causes the small airbells to form and prevent developer reaching the whole of the emulsion surface evenly. The addition of wetting agent reduces the surface tension considerably. The amount needed varies, a fore-bath needs between 1 : 1,000 and 1 : 5,000, whereas, if it is added to the developer itself the amount needed is very much less. Wetting agents are frequently used *after* washing to prevent drying marks, for such purposes the concentration required is rather higher. If the film is immersed after washing in a 'Gevatol' solution composed of 5 c.c. 'Gevatol' in 500 c.c. water it will dry rather more rapidly and evenly.

★ Recommended developers

Gevaert supply the 'Refinex' and 'Nogranol' prepacked developers, in packings suitable for both professional and amateur. 'Refinex' yields negatives full of detail and of fine grain. Because of its compensating developing action it guarantees satisfactory separation of both shadow and highlight details even in the most extreme types of 'against-the-light' shots. Similarly it will compensate for errors in exposure and is, therefore, particularly good for developing long rolls of film where individual treatment for each exposure is impossible.

'Refinex' keeps well and gives a long working life before exhaustion. A quantity of 70 litres (15 gallons) used *with replenisher* will develop 3,000 120 or 620 roll films. 'Refinex' gives a clear solution when made up with hard water. In addition it contains a disinfectant which inhibits deterioration due to bacterial growth.

'Refinex' is specially suitable for amateur and professional tank development of roll films. 'Nogranol' is an ultra fine-grain developer. It possesses compensating properties similar to 'Refinex', is non-toxic, does not stain, inhibits bacteria and keeps for a long time. Like all ultra fine-grain developers containing silver

halide solvent and producing a semi-physical action, it clouds gradually because of the formation of colloidal silver, but this 'milkiness' has no effect on the developing properties of the solution, although when the solution is old the colloidal silver may need to be carefully swabbed off the emulsion surface before washing or drying.

'Nogranol' is particularly recommended for developing miniature films, and also for roll films which are to be enlarged considerably.

For those who wish to make up their own solutions we suggest:

For developing roll films: formula G.206.

For miniature films, and for finer grain with roll films: G.224.

'Studio' developers are compounded specially for the portrait photographer. Two varieties are available: 'Studio Normal' which gives normal negatives with sparkle and well defined details. 'Studio Normal Replenisher' is available separately in packings to make three litres of replenisher.

'Studio Special' which gives soft negatives with well separated tones. This developer is intended particularly where a reduction in contrast is desired because the subject has a wide brightness range, for example weddings, first communions, etc. 'Studio Special Replenisher' is supplied separately in packings to make three litres.

★ Recommended fixers

Use an acid fixing bath which stops development immediately. Gevaert 'Acidofix' fixing powder is specially suitable. Fixing baths can also be made up to formulae G.301 and G.308. G.308 is intended for tropical use, i.e. when the temperature of the wash water exceeds 75°F. (25°C.). Fixing time: 10–20 minutes according to solution strength.

Outline of processing

Films and plates are best developed as soon as possible after exposure. As time goes on the exposed portions of the sensitive layer have an effect upon the unexposed parts and can cause fog.

The material of which metal and wood darkslides are made (or the paint with which they are finished) can also in time have a deleterious effect upon the sensitive material. If for some reason it is impossible to develop promptly do not leave flat films or plates in holders but return them to the package wrapped in the black paper *which they were supplied in*, stacked emulsion to emulsion or, better still, separated by sheets of black paper. Exposed flat films and plates should not be stored with their sensitive surface in contact with the backing of other plates or films because any impurities such as dirty finger marks which can easily be present on the back of films and plates will probably have a bad effect on the emulsion (see negative faults).

When away on a trip special care should be taken in repacking plates to see that they cannot rub against each other as they are jostled about because this will produce abrasion marks and scratches.

Carry out the processing in an orderly manner as follows: Get everything ready *beforehand*, then put out all the lights and see that there is complete darkness. Then put on the safelight (but *only* if orthochromatic material is being processed).

Remove the film or plate from its protective wrapping and immerse it face up in the dish or tank. Take care that the emulsion is completely covered by developer. If the exposure has been correct the image will appear slowly and regularly.

The highlights appear first, then the mid tones, while the shadows remain clear. After about 4 min. ('Gevachrome 32' studio film developed in 'Studio Normal' at 68°F.) the image gets stronger and the shadow areas which were previously blank begin to fill in. The film or plate can then be lifted from the solution to check the progress of development by inspection against the safelight. It should look contrastier at this point than it will after fixation and the dark areas should be observable from the back – going right through the emulsion layer.

Rinse the film or plate quickly in water (or an acid stop bath) and place it straight away in the fixer, where it should stay for at least ten minutes with occasional agitation. In this bath the emulsion will lose its milky appearance and become completely transparent.

As soon as it has cleared the white light can be switched on. The film or plate should not be removed from the fixing bath yet but should be fixed for at least as long again as it took to clear.

To finish up with the film or plate which is now called a 'negative' is washed. To ensure the negative keeps well it is essential that it be properly washed after fixing. Wash for 30 minutes in running water or in at least 12 changes of still water, 10 minutes per change. Increase these times if the water is below 60°F. (15°C.). The more frequently the water is changed the more the washing can be speeded up, although the upper limit is set by the time taken for the fixer to diffuse out of the inner layers of gelatine. This process can also be speeded up by bathing for a few minutes in salt solutions such as 1 : 100 sodium sulphite. (To increase the changes of water decrease the size of the washing tank.)

By using a cascade washing system, or one where the fresh water flows continuously past film with increasing concentrations of fixer in it (counter-current system) the same efficiency of washing can be obtained with the use of much less water, the efficiency increasing as the number of steps in the cascade increases. The counter-current system is simply a cascade with an infinitely larger number of steps.

The film or plate is then dried in a dust free atmosphere by warm (but not too warm) dry air. If dried by heat they should not be too near the source of heat and the air temperature should not exceed 120°F. until at least the films are partly dry as wet gelatine readily melts above this temperature. When partly dry, however, it can in emergencies withstand higher temperatures, although this may 'cockle' the base. When rapid processing is essential, as is often the case in newspaper work, washing can be curtailed to 10–15 minutes in running water, or the negative can be printed wet and washed and dried afterwards. The film

or plate can then be soaked in alcohol (methyl) for two minutes and can then be dried very rapidly.

The foregoing instructions apply to *correctly* exposed negatives. If the negative has been *over-exposed* the image will appear rapidly in the developer and will soon become black all over. If this happens do not leave the film or plate in the developer any longer but rinse it quickly and fix and wash normally as outlined above. The negative you will finish up with will not be a really good one, but provided the over-exposure was not too great it will give quite a usable print.

If the negative has been *under-exposed* development will proceed slowly. The highlights, that is the black parts of the negative, will come up quickly enough it is true but the mid-tones, and particularly the shadows, may not appear at all. The best course to take as soon as under exposure is diagnosed is to dilute the developer so that the development of the highlights is arrested and to wait until the negative shows some density in the shadow areas. Some workers advocate removing the negative to a water bath and leaving it there for several hours, especially for very contrasty subjects such as church interiors with stained glass windows, etc. The resulting negative will not give a completely satisfactory print and the beginner needs to convince himself by better experience that under-exposure is one of the major faults he ought to learn to avoid scrupulously.

Methods of development

Two different methods were described in Part I of this book for developing films and plates.

★ Tray development

(see page 94.)

Used by amateurs for developing sheet film and plates.

★ Tank development

(Amateur-tanks, loaded in darkness, processing thereafter in the light.)

In recent years small developing tanks have come into favour. These are generally made of hard black plastic and are light-tight. The most common form has a plastic spiral inside like a drum with two sets of spiral grooves between which the film can be slipped. The loaded spiral is then placed in the tank body and the lid fitted on tightly. This is provided with a light-trap funnel in its centre into which first the developer, then the rinse water and finally the fixer can be poured. At the edge of body and lid is a spout, similarly light trapped, to allow the solutions to be poured out. Washing is carried out by placing the spiral with the centre funnel underneath the tap.

To load the film into the spiral is not always easy and it is wise to practise with a waste length of film, making sure that the end is bent as directed by the suppliers of the tank and following all their instructions carefully. Some makers of tanks provide patented catches to assist loading, others allow partial rotation of the two cheeks of the spiral and others provide for a spring assisted up and



Correct exposure
Normal development

Correct and Incorrect Negative Exposure

It is a good idea to practise judging negatives quickly at a glance for quality and defects, particularly to see whether they have been correctly or over- or under-exposed.

These reproductions will give you a good idea to start with even though the range of brightnesses which can be shown on the book paper is much less than the range which the different negatives will exhibit.



Under exposure
Normal development



Under exposure
Prolonged development

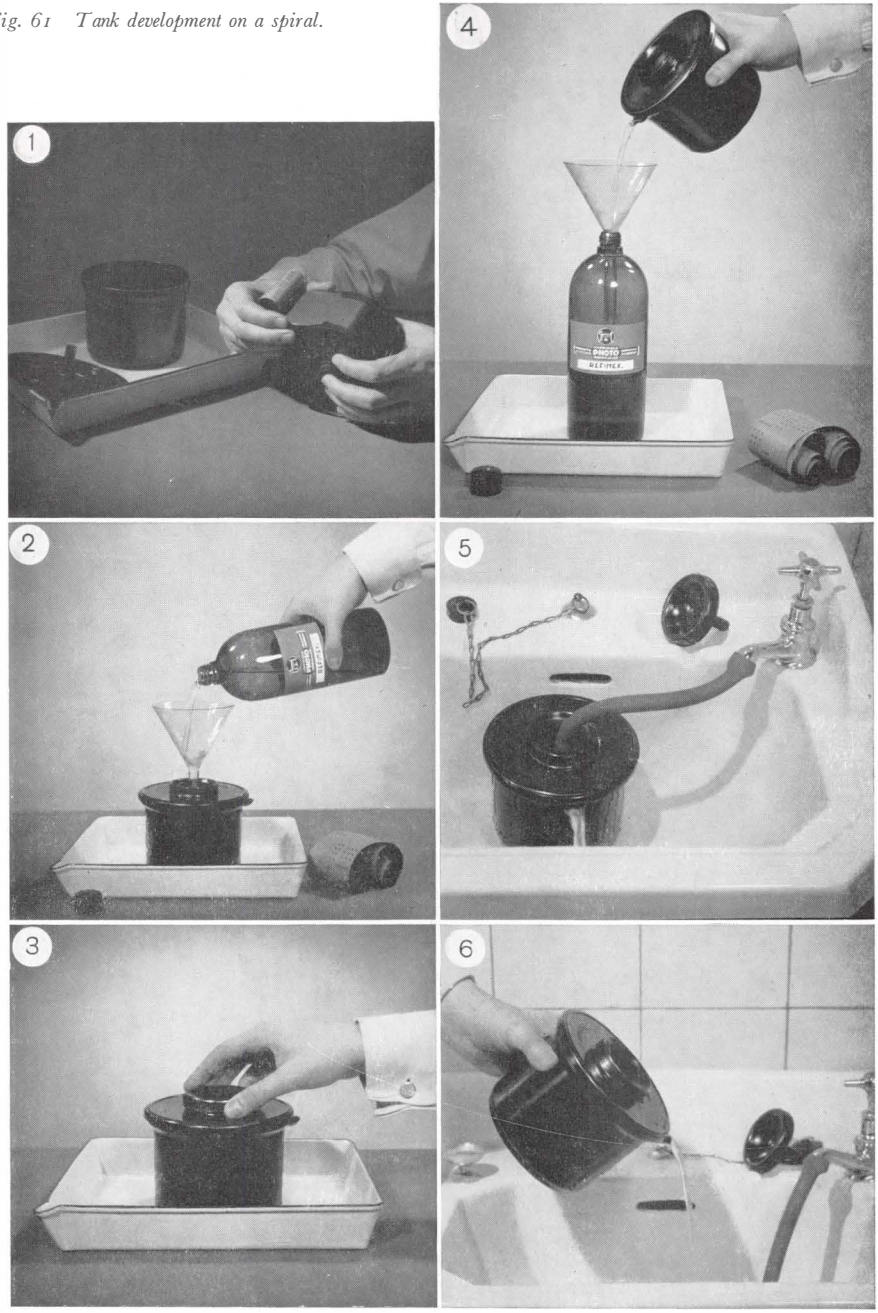


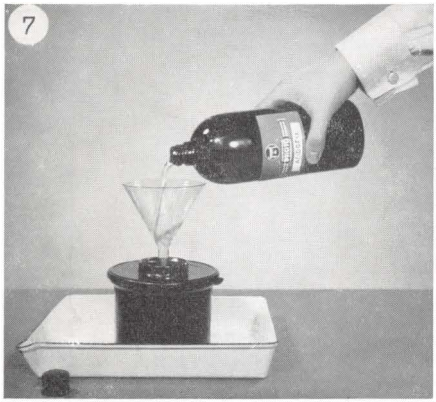
Over exposure
Normal development

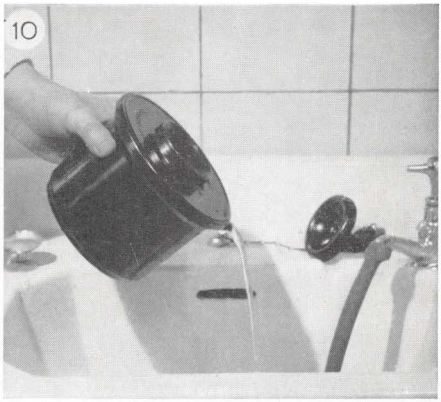


Over exposure
Shortened development

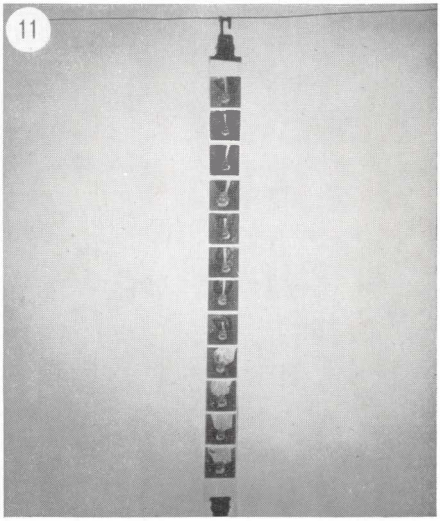
Fig. 61 Tank development on a spiral.

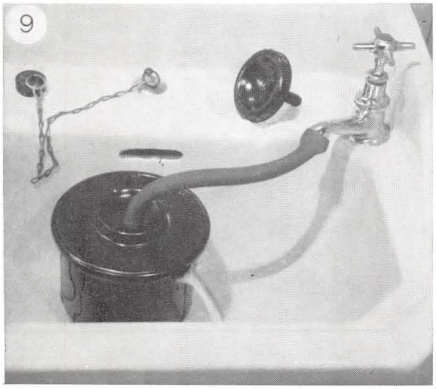












1. Loading the spiral with film
2. Filling the tank with developer
3. Rotating the spiral with the knob
4. Pouring off the developer
5. Rinsing briefly in water
6. Pouring off the rinse water
7. Filling the tank with fixer
8. Pouring off the fixer
9. Washing the film
10. Pouring off the wash water
11. The film hanging up to dry



Shooting the sun – Photo : J. Allan Cash

down movement of the spiral in the outer body during development to promote agitation.

There are also available several makes of tank which permit all the operations, including loading the film, to be done in full daylight. The makers' instructions must be carefully followed.

It sometimes happens that development in these tanks causes small clear areas on the negative. These are caused by bubbles of air – 'air bells' – which are trapped between the convolutions of the film and prevent the developer from reaching and acting on these parts of the emulsion. This fault can be prevented by agitating the tank and turning the film spool in the tank in the manner suggested by the maker and by giving the loaded tank several sharp knocks on the table as soon as the developer has been poured in. The film can also be soaked in water before development to ensure even action in the developer, but the use of frothy water may increase 'air-bell' trouble, and the pre-soak is generally unnecessary with modern developers containing wetting agent. Most small tanks of this kind are so made that rotation of the spiral also sets up vertical agitation or currents in the liquid. This movement, however, is generally not sufficient to remove air-bells.

After development rinse, wash and dry the film according to the maker's instructions which are usually printed on the package, or given inside.

The methods given above are only suitable for roll films and 35 mm. miniature film.

★ Tank development (professional) (see page 96)

Development in large tanks is the favoured method for professional work. The tank – of 2–3 gallons capacity (10–15 litres) – can accommodate at one and the same time several roll films (on spirals), miniature films, cut films or plates (in hangers). Gevaert 'Refinex' developer is very suitable for this method of development as it gives – with normally exposed material – fine-grained negatives which are full of detail. The tanks of plastic, stainless steel or porcelain, should be thoroughly cleaned out, especially at the bottom, before filling with developer. When full the frames on which roll films, 35 mm. films or sheet films are hung are placed in the tank, or plates are slipped into the sets of vertical grooves provided. After they have been raised and lowered several times they are left for some time, agitating about once every minute. In the meantime it is possible to go out of the darkroom to do something else. After several minutes, or longer, according to the type and dilution of the developer used, the progress of development can be checked (*except* for panchromatic materials). It is advisable to agitate the films and plates. This is carried on for as long as necessary. To decide the total time of development it is best to refer to the time-gamma diagrams which show the time required for a given temperature and for the gamma desired. In using these diagrams it is worth remembering that the gamma will be increased if the time given is exceeded, and the graininess will also increase. Development should be carried out between 60°–75°F. (15°–25°C.).

Development time

This depends on several factors. If the exposure given is correct then the development time should be chosen so that the required degree of contrast (gamma) is just reached during this time.

With sheet film and plates, even in professional tanks, individual treatment of every plate is possible and the development can be carefully adjusted to suit the brightness range of each individual exposure by choosing the most suitable developer and by altering the time of development so that this gives, for example, a low gamma for scenes of great lighting contrasts and a higher gamma for less contrasty scenes. In general it will be found that two developers are all that is necessary since there is a wide range of contrasts in papers with which to adjust minor variations. For commercial and industrial work a fine grain compensating type of developer such as 'Refinex' or G.206 will suffice. For portraiture, one tank of 'Studio Special' and one say of 'Refinex' will probably be more suitable.

The individual negatives on roll films and 35 mm. miniature films in long rolls cannot be subjected to individual treatment as a general rule. Development of these is, therefore, generally carried out in closed tanks. In such cases an average gamma is chosen, sometimes termed ideal-gamma. The gamma usually used is 0·9 for rollfilms and 1·0 for miniature films. The gamma does not depend entirely on the developer used and the time of development. Temperature plays a big part. At high temperatures the gamma required is reached much quicker than it is at normal temperatures and vice-versa. There are limits it is unwise to exceed. The best normal temperature to adopt is 66°–68°F. (19–20°C.) and development above 75°F. (25°C.) or below 60°F. (15°C.) should be carefully avoided. Another factor which influences the degree of development very strongly is the amount of agitation during development. When the film or plate is continuously in motion (tray development, or development in small amateur tanks unless these are left still) the layer of developer in contact with the emulsion is continually and rapidly renewed and this keeps the development going at full activity and as a result the gamma required takes much less time to reach than is the case with a solution which is only agitated occasionally (e.g. development in professional sized tanks). Comparative tests have shown that under such conditions of development the same gamma can be reached in a time 25% less than when the film is continuously in movement than that required when the developer is only agitated occasionally. To convert tank times to tray times, or to times suitable for amateur tanks where the tank is agitated continuously or vice-versa, use the following rules:

Tray time = tank time less 25%

Tank time = tray time plus 30%

Finally the *degree of exhaustion* of the solution must be taken into account. A fresh solution develops more quickly than one which has been used and, therefore, has a higher bromide content. This is usually compensated for either by increasing the development time as the solution becomes used up or by replenishing the bath with a suitably compounded solution.

The first method can be used by amateurs who use 'Nogranol'. For each 120 (620) roll film or 36-exposure length of 35 mm. film developed in 1 litre of the developer solution an increase in developing time of 10% is required. As a general rule about ten films can be developed in 1 litre of 'Nogranol'. The time will then be doubled. After this discard the solution.

The second method is used for the larger tanks used by professionals. The solution is maintained at a fixed level, not with water or developer but by the addition of replenishing solution ('Refinex', 'Nogranol Replenisher', etc.). The concentration and chemical balance of this solution is such that used with reasonable care, according to the instructions, the activity of the developer and consequently the time of development will remain constant. Developers can retain their activity for long periods in this way. Replenishing solutions are not packed in small quantities being only suitable for use by professionals.

In cases where the developer is maintained continuously at 70°F. and only infrequently used for development – such as may occur in a scientific laboratory – it is essential to fit a well-tailored floating lid which can easily be made from paraffin wax, both to reduce oxidation and to reduce evaporation. If evaporation rather than solution 'carry-over' is severe the bath should be replenished with water or diluted replenisher. If on the other hand 'carry-over' is severe due to lack of adequate draining of films after development then replenishment with developer is advised at least to start with. Solutions can be kept in perfect condition for at least six months with these precautions.

Diagrams and their use

Now we have been over the main important points about development, let us have a look at the data again arranged in the form of a simple diagram which can be easily and rapidly consulted.

★ Time-gamma curves

As has already been said the value of gamma increases as the development is prolonged. This relation can be plotted on a graph which will show how the gamma changes with the duration of development. A time-gamma curve can be prepared for each emulsion and each recommended developer.

What use is a time-gamma curve in practice?

Let us look at the two recommended developers for 'Gevapan 30' sheet film – 'Studio Special' and 'Studio Normal' (see figs. 62 and 63).

It will be seen that a gamma of 0·8 (points which are ringed round) requires 7 minutes development in 'Studio Special' whereas 3 minutes is sufficient to give the same gamma in 'Studio Normal'. We conclude therefore that 'Studio Normal' works quicker than 'Studio Special' since it gives the same result in a shorter time. (This by the way is not necessarily a good reason for preferring it.) We can also see that a higher gamma is reached with 'Studio Normal' ($\gamma = 1 \cdot 1$) than with 'Studio Special' ($\gamma = 0 \cdot 9$).

The 'Studio Special' developer used in conjunction with 'Gevapan 30' sheet film, therefore, offers a *wide variation in treatment*, since the increase of gamma with development time is relatively slow, an increase of developing time from 4 minutes to 10 minutes only increases the gamma from 0·55 to 0·95, so that it

is not unreasonable to say that a small error in the developing time will not result in undesirable variations in the ensuing gamma.

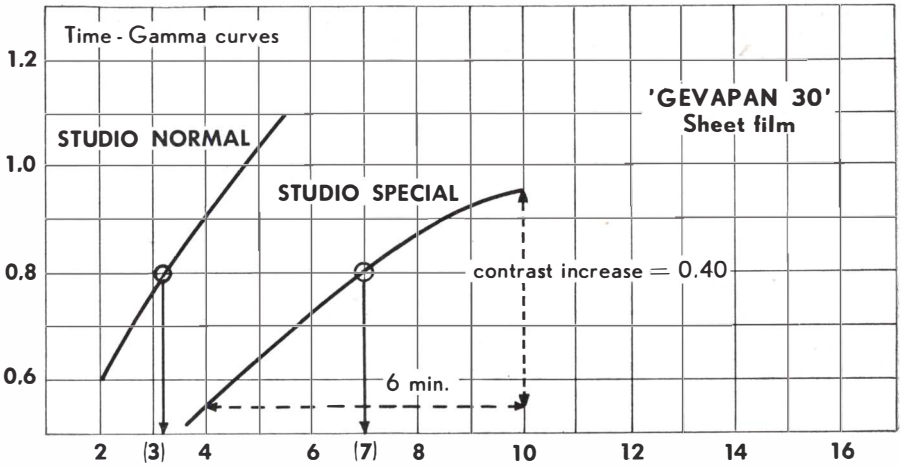


Fig. 62 Time-gamma curves for 'Gevapan 30' sheet film.

After the curves for a sheet film let us now look at one for the 'Gevapan 30' plate. Here matters are rather different. It is obvious at once that the same 'Studio Special' developer has a much more rapid action and the increase of

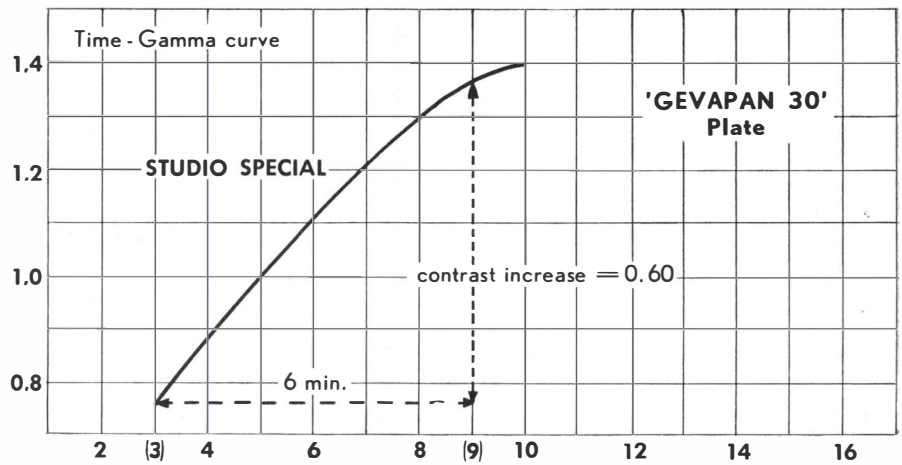


Fig. 63 Time-gamma curve for 'Gevapan 30' plate.

gamma with time of development is much steeper. The final gamma is also much higher ($\gamma = 1 \cdot 4$).

From a careful scrutiny of these two diagrams it can, therefore, easily be

deduced that the 'Gevapan 30' plate is much more contrasty than the sheet film, i.e. reaches a given gamma quicker and has a higher final gamma.

It should be pointed out that the gamma does not go on increasing indefinitely. After a time which is typical for each developer a maximum value is reached: 'gamma-infinity'. On the diagrams this is the value where the curve becomes horizontal. You will notice that the curves given are not as a rule carried on so far. There is a good reason for this. Contrast (gamma) is not the only thing that matters. As the development is prolonged both the graininess and background fog increase and both reach undesirable levels before the maximum gamma is reached.

★ Gamma-time-temperature diagrams

Gamma-time curves are generally given for one specific temperature (68°F., 20°C.) but of course it frequently happens that one wants to work at other temperatures.

For this purpose curves which show gamma against time *and* temperature are most valuable and give the required information immediately. They show the time of development needed – at a certain temperature and for given developer – in fresh condition – to give negatives of a given gamma (contrast).

PROCESSING FILMS

Sheet films

Each piece of film is notched to assist in identifying the emulsion side in total darkness. When the film is held so that the notches are at the top right hand side the emulsion is facing-up towards the operator. Two notches mean orthochromatic sensitivity, three notches panchromatic.



Fig. 64a Orthochromatic film: 2 notches.



Fig. 64b Panchromatic film: 3 notches.

Flat films may be tray developed in the following way. Slip the film smoothly under the surface of the developer and give the tray a gentle rocking motion for several seconds and then cover it with a piece of card. Remove the card occasionally to check the progress of development (only when orthochromatic film is in use) and agitate the tray at least every 2 minutes, or every minute if a time of less than 5 minutes is being used. If the exposure was correct the negative image will appear slowly and regularly. The highlights come up first then the mid tones while the shadows will remain with only a low density.

Hang the films up to dry by pinning a corner to a shelf using a clean ordinary domestic pin, or a special photographic push pin. They can also be suspended from a line using wooden, plastic or metal spring clips. To develop flat film in

larger tanks they must be clipped or slid into special holders or hangers (these are available commercially).

Roll films

Roll films are usually developed in spiral developing tanks. See the description given on p. 180, although in trade developing and printing houses large deep tanks are used. Those who do not have one of these spiral tanks can use the following 'see-saw' method in a deep tray: arrange 4 trays ($\frac{1}{2}$-plate size is about the best) in a row. The first with water, the other with developer, rinse water or solution and fixer, in that order. Make sure you can identify them in the dark. The first tray of water is to pre-soak the film before development, to assist in handling the film which is 'springy' until wet and to ensure even development. When everything is ready put out the light and put on the red safelight (only for orthochromatic film – it is a good idea to use a 'chrome' or 'ortho' film for your first attempt). Then unwind the film and detach the film from the paper backing to which it is attached by a strip of tape. Take one end of the film in each hand, see that it is not twisted and pass it to and fro through the first tray of water several times from end to end so that it is completely soaked and so that all the air bubbles which will have been formed on the surface have disappeared. The film will then sag more easily and will stay under the liquid at the lower end of the loop and the loops can be held so that the back of the film does not rub unduly against the edge of the trays.

Then 'see-saw' the film in the tray of developer by raising and lowering each hand. The image will soon show up and as soon as the development looks about enough, or after the time decided on, rinse the film (and your fingers) in the third tray – of water – and then repeat the 'see-sawing' in the fixing bath, for long enough to fix it completely (twice the clearing time).

Development table

1. The times given apply only to *fresh* solutions or solutions which have been correctly replenished with the recommended replenisher solution.
2. If the solution has not been replenished (i.e. amateur packings) the times given in the table should be increased by 10% for each film developed per litre of solution.
3. Dish development means with constant agitation. Tank development means agitation for the first 30 seconds and thereafter for 5 seconds every 2 minutes.
4. Development in spiral tanks can be assumed to be the same as tray development *provided that* the spiral or tank is kept continually in movement. If the maker of the tank recommended intermittent agitation the time of development decided on should lie between the times given for tray and tank.
5. Solutions should be used up within a reasonable time even if kept in brown coloured tightly corked full bottles. The times only apply to solutions used within 6 months of being made up and within 3 months of their last use if not replenished.

Films	*Recommended developers*	*Gamma (approx.)*	*Development times in minutes*					
			Tray			*Tank*		
			60°F.–16°C.	*68°F.–20°C.*	*75°F.–24°C.*	*60°F.–16°C.*	*68°F.–20°C.*	*75°F.–24°C.*
Roll film 'Gevapan'	'Refinex'*	0·9	9½	6½	4½	12½	8½	6
	'Nogranol'**	0·9	14	10	7	19	13	9
	G.206*	0·9	14	10	7	19	13	9
	G.224**	0·9	26	16	10	35	21	13
Miniature films 'Gevapan'	'Refinex'*	1	9½	6½	4½	12½	8½	6
	'Nogranol'**	1	14	10	7	19	13	9
	G.206*	1	14	10	7	19	13	9
	G.224**	1	26	16	10	35	21	13
Sheet films 'Gevapan 30' 'Gevapan 33' 'Gevachrome 32'	'Studio Normal' or G.214	0·9	5	4	3	6½	5	4
	'Studio Special' or G.215	0·8	9	7	5	12	9	6½
Sheet film 'Gevapan 36'	'Studio Normal' or G.214	0·8	8	6	4½	11	8	6
	'Studio Special' or G.215	0·8	13½	10	7½	18	13	10

*=Fine grain developer.
**=Ultra fine grain developer.

After development fix and wash as instructed on page 179.

PROCESSING PLATES

Loading darkslides (plateholders)

Always hold plates by their edges when unwrapping them. Fingers should not be allowed to touch the emulsion side. Don't put down one plate on top of another as small fragments of glass or emulsion may be left behind and cause subsequent defects.

Keep them well away from the safelight even if it has practically no effect and the more sensitive the plate is the more careful you should be, for the same reason never leave plates lying about uncovered or boxes without the lid on. Care and method prevent many disappointments. Panchromatic plates should be unpacked and loaded into darkslides in complete darkness.

The plate as it is taken from the packet is completely dust-free so keep your camera and darkslides clean from dust also. This fight to keep everything free of dust is important because practically all the pinholes on negatives are caused by dust on the emulsion at the time of exposure. How can the emulsion side of a plate be identified? If you know how they are packed you cannot go wrong.

Plates are packed in fours *with the sensitive emulsion of each pair* face to face.

They are not actually in *contact* because they are held slightly apart by small strips of black paper which are bent round on two opposite sides at the edge of the plates. Fig. 65 gives a diagrammatic view of the way the 4-plate packets are assembled.

If for any reason a plate is put down and the emulsion side is lost there are two ways of finding it out, both of which must be used with extreme care. The first is to pass the side of the hand opposite the thumb, dry of course, gently over one side, the emulsion side is generally much smoother than the backing on the glass plate. The other method, which is more satisfactory if you have experience of the plate in use, is to moisten a corner of the plate on *both* sides with the lips (some people use their teeth). After a few seconds the emulsion side becomes 'tackier' than the backing. Avoid breathing heavily over the plate and it is wise to wipe any dye off your lips when emerging from the darkroom, especially if it is a red backing dye.

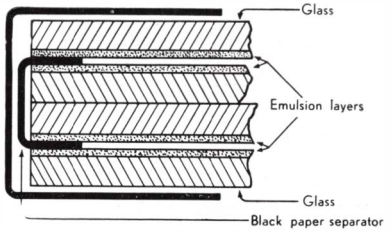


Fig. 65 The way plates are packed. On opening the packet the top plate is emulsion down, the second plate is emulsion up, the third is like the first, emulsion down, and the fourth emulsion up. It is impossible to get confused.

Always tap a plate sharply by its edge against the loading table or shelf to remove any small particles of glass or emulsion.

The first time you use a new camera you should make yourself thoroughly familiar beforehand with the way it works. This goes for the darkslides as well.

Have a good look at the way the darkslide operates in daylight before you go into the darkroom to load it with a plate. If you do this you will not run the risk of damaging them by trying to force something shut in the dark.

Processing

Plates can be processed in dishes or tanks. Read what has been said on this subject on pages 94 et seq.

They can be washed in a small tank which is provided with vertical grooves to hold the plates.

To promote even drying it is best to stack them in suitable plate drying racks a reasonable distance apart with one plate to every other set of grooves. If placed too close together plates do not dry uniformly and this gives as a result darker areas; the parts which dry faster being darker.

Development table

1. The times given below apply to fresh solutions or solutions which have been correctly replenished by the addition of recommended replenisher solution.
2. If the solution is not replenished then the times given should be increased by 10% for every six $\frac{1}{4}$-plates ($3\frac{1}{4} \times 4\frac{1}{4}$) or the equivalent that are developed in 1 litre.

Photo: Louis Stettner →

3. By tray development is meant: development with constant agitation. By tank development: agitation for the first 30 seconds, thereafter for 5 seconds every 2 minutes.

Plates	*Recommended developers*	*Gamma (approx.)*	*Development times in minutes*					
			Tray			*Tank*		
			60°F.–16°C.	68°F.–20°C.	75°F.–24°C.	60°F.–16°C.	68°F.–20°C.	75°F.–24°C.
'Gevachrome 32'	'Refinex' or G.206	1	14½	10	6½	19	13	8½
'Gevapan 30'	'Studio Special' or G.215	1	5½	4	2½	7	5	3½
'Gevapan 33'	'Refinex' or G.206	1	20½	14	9	27	18	12
	'Studio Special' or G.215	1	7	5	3½	9	6½	4½
'Gevapan 36'	'Studio Special' or G.215	1	11½	8½	6	15½	11½	8
'Replica 23'	'Refinex' or G.206	1	7	6	5½	9½	8½	7½
	'Metinol U' or G.251	2·5	3½	3	2½	4½	4	3½

After development fix and wash the negatives as described on p. 179.



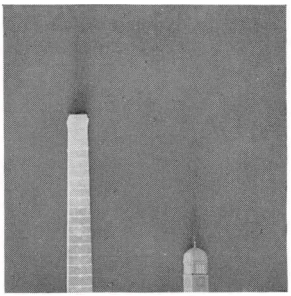
FAULTS IN NEGATIVES

Some typical negative faults.

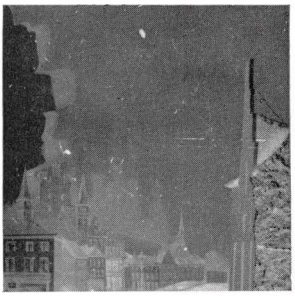
(Caption numbers correspond to the numbers used in the table which follows)



9. Partial reversal of image during development.



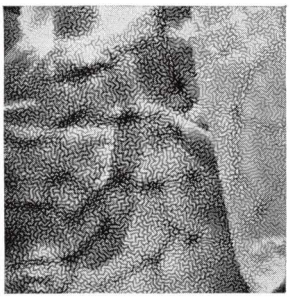
12. Streamers due to lack of agitation.



13. Dust on emulsion at time of exposure.



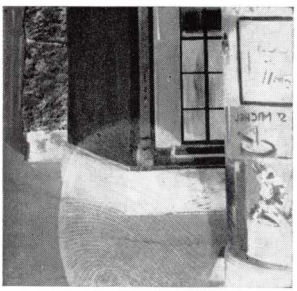
16. Air bells during development.



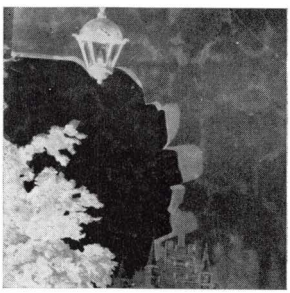
18. Reticulation (of emulsion).



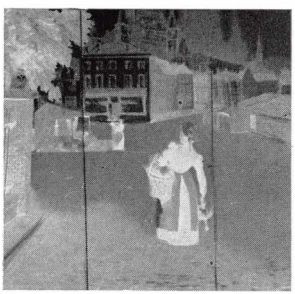
19a. Finger print before development.



19b. Finger print before fixation.



20. Irregular density patterns.



27. 'Tram-lines' – parallel scratches.

Fault	*Cause*	*Prevention and Remedy*
1. Negative too thin, although with good shadow detail	Development too short, or developer too cold	Develop correctly Remedy: Intensify with formula G.526 and/or print or enlarge on hard, very hard or ultra-hard paper
2. Negative too dense (clear areas too dense), shadows veiled over	Over-exposure and over developed	Develop correctly Remedy: reduce in ferricyanide (formula G.501)
3. Negative too thin (highlights too dense), image appears slowly	Under-exposure or developer too cold or exhausted	Better to have *over*-exposure than *under*-exposure Remedy: None, try reducing with persulphate formula G.503
4. Negative flat and lacking in contrast; on development the image 'flashes up' quickly	Over-exposure or too vigorous a developer, or developer too warm	Add 10% solution Potassium Bromide to developer, a few drops at a time Remedy: Intensify with formula G.526
5. Negative fogged (neutral colour)	Many causes: Light leaking Unsafe darkroom lamp Material too old or stored badly Left too long in darkslide Developer too strong or too warm Lens flare or camera flare	Look up the general precautions given on pages 175 et seq. Remedy: Generally none A light general fogging will probably not prevent reasonable prints being made Check the camera and clean the lens and filters and use a lenshood
6. Fog in rebates only (those portions of the film or plate by which it is held and which are generally not exposed to light)	Generally: material too old. With roll films: badly wound film or a bad film spool	This fogging rarely intrudes far on to the picture area, and only spoils part of the picture Remedy: Use fresh material. Check winding of camera
7. Fog marks or streaks	Camera, darkslides or wrapping not light-tight. Pinholes in bellows and shutters which do not close completely or strained camera backs are frequent causes of this trouble	When loading plates, repack those not used *very* carefully. Check the light tightness of all apparatus very carefully against a strong light with a dark cloth over the head to exclude light from the eyes Remedy: None
8. Yellow fog or Dichroic-fog. (Green by reflection, red by transmitted light)	Too prolonged development in exhausted developer Fixer (hypo) contaminating the developer, or too much developer carried over into fixer	Follow instructions carefully. Use a stop bath Remedy: After well fixing and washing immerse the negative for 5 minutes in a (1 : 1,000) solution of potassium permanganate and then clear in a 10% sodium bisulphite solution



Photo: Bert Buurman

Fault	*Cause*	*Prevention and Remedy*
9. Negative partially reversed The negative appears as a positive Sometimes only the highlights are reversed	Prolonged development in unsafe light or accidental exposure to light part of the way through a long development (e.g. for underexposure)	Follow instructions carefully Remedy: None
10. Small black spots	Undissolved particles of developer (metol, hydroquinone, etc.) or alkali which have stuck to emulsion. Small splashes of developer on the emulsion before development	Make up developers properly according to instructions Everything should be properly dissolved, before use, or filtered If you want to add something to the developer (try not to do this during development), see that it is properly dissolved
	Pinholes in darkslide	Check darkslide Carry out operations carefully and correctly Remedy: Retouching on prints
11. Dark (or light) lines parallel to short dimension of the plate	After exposure the plate has been placed in contact with the corrugated cardboard in which plates are packed	Pack exposed plates emulsion to emulsion, as packed originally Remedy: None, unless the print can be retouched
12. During tank development clear streamers show *below* the dense portions of the negative	Film (or plates) have not been agitated sufficiently during development	Agitate the film or rock the tank Remedy: None, except retouching print
13. Pinholes (small, clear dots on the film)	Dust on the emulsion preventing light reaching it Small bubbles are produced in the emulsion by carbon dioxide liberated by the action of acetic acid in the stop bath on the alkali of the developer. The stop bath is too strong or badly mixed	Dust on darkslides. Keep them dust-free Prepare solutions correctly according to instructions Remedy: Retouch with soft pencil, or knife on print
14. Large irregularly shaped area not developed, or lighter than the rest	Developer has not completely covered the negative, all the time	Use sufficient developer Remedy: None
15. Large round-shaped area darker than the rest of the negative	Irregular drying Negatives are too close to each other, or too great changes of temperature during drying	Remedy: Re-wet the negative and dry slowly and evenly Not always completely efficacious

Fault	*Cause*	*Prevention and Remedy*
16*a*. Small, round areas clearer than rest of negative	*a*. Air bells (bubbles) on the emulsion or the developer which cannot reach these spots	*a*. Slide negatives slowly and evenly into the developer, or pour developer on to plate Pre-soak or add 'Gevatol' to developer (1 : 100) Agitate the dish gently during development Swab off the remaining bubbles with a piece of cotton wool When using a spiral tank knock this sharply several times against the bench during development, especially at the start
16*b*. Small transparent spots	*b*. Microbiological action on the wet film during drying	*b*. Dry in a well-ventilated place, not too warm. If a prevalent fault in tropical country, harden in bath G.354
16*c*. Small, rounded clear areas	*c*. Splashes of fixer on film *before* development	*c*. Be more careful Remedy: Retouch with soft pencil
17. Dark circles (Moon or crescent shape)	Flare images of sun or other light in 'against-the-light' shots	Use an efficient lenshood Remedy: Local reduction
18. The emulsion layer is crazed with a pattern of numerous irregular lines (Reticulation)	Abrupt swelling and contraction of the gelatine layer by: 1. Going from a very acid to a very alkaline solution or vice versa 2. Going from a warm to a cold solution or vice versa	1. Use the recommended solutions in the way laid down 2. Keep solutions and wash water at temperatures which do not vary by more than 10°F. (4°C.) Remedy: None
19*a*. Fingerprints (dark)	With plates this is usually caused by leaving plates which have been exposed but not developed for two or three days with the emulsion against the glass side of another plate with films and plates Handling with fingers contaminated with developer before or after exposure and before development	Pack exposed plates emulsion to emulsion (as originally provided) until developed Always rinse and dry hands which have been in solutions Follow instructions properly Remedy: None
19*b*. Fingerprints (light)	Handling with fingers contaminated with fixer before or after exposure and before development	Always rinse and dry hands when they have been in contact with solutions Remedy: None

Fault	*Cause*	*Prevention and Remedy*
20. Negative covered with a network of density patches with or without a honeycombed appearance	Negative not agitated during development or developer badly mixed or diluted too much	Rock the tray during development Follow instructions Remedy: None
	Negative left too long in rinse water	
21. Striations: generally like marbling	Developer too dilute or containing too much sulphite	Add 2g. metol per litre to developer Remedy: None
22. Dark markings, tree shaped	Static electricity discharged on the film due to friction during winding (too rapid or stiff roller or winding) Too rapid unwinding in dark room especially in dry air conditions	Wind slowly, check the camera mechanism Remedy: Retouch positive
23. Milky appearance from glass or film base side of negative	Incomplete fixation: too short a time or an exhausted fixing bath. An overall matt white appearance can be caused by using water that is far too hard	Refix thoroughly and do not use exhausted fixing bath, or one at too low a temperature Immerse in a weak solution (2%) of hydrochloric acid Use 'Calgon'-sodium hexametaphosphate to remove hardness in water before making up
24. The emulsion surface has a rough granular appearance	Developer and/or fixer made up with over-hard water Insufficient rinsing between development and fixing or the use of over-hard water to wash in	Use soft water (or use softening salts, etc.) Remedy: Immerse in a 2% solution of hydrochloric acid and swab off *gently* with cotton wool
25. Dry negative shows fine salt crystals or deposit	Insufficient final wash Residual hypo salts are drying out on the surface	Wash properly Remedy: Rewash thoroughly
26. Emulsion leaving edges of plate or film ('frilling') Emulsion melts Blisters in the emulsion layer	Developer or fixer too warm Too alkaline Too big a difference in temperature between solutions and wash water	Develop or fix at 68°F. (20°C.) Avoid great differences in temperature (more than 10°F.) Make up solutions correctly Harden between development and fixing formula (G.356)
27. Roll films and 35 mm. miniature films: 'Tramline' scratches along the length of the film	Winding too rapid Jammed roller Dirt in cassette trap Rough or rusty roller or film guide 'Clinching' roll film on unloading	Wind on deliberately Free mechanism, clean all film containers properly Clean and refinish rollers and guides Never wind loose spools tightly on themselves, wrap up quickly and put away Remedy: Retouch negative or print

Fault	*Cause*	*Prevention and Remedy*
28. Scratches and abrasions of all sorts on the film	Generally caused by specks of dust and grit embedded in film which damage the emulsion when the film is wound on in the camera	Clean the inside of the camera *regularly* with a brush (or insoufflater) Remedy: When enlarging try this method: Before putting the film into the negative carrier put a few drops of carbon tetrachloride on the glass. Put the negative down and squeeze out the air bells. Put a few more drops on to the film and close down the second glass, also removing the air bells. Then enlarge. The scratches and abrasions will be far less visible, especially if a diffuser enlarger is used. A number of other proprietary varnishes and media are also available, but carbon tetrachloride evaporates afterwards leaving no trace
29. Brown coloured fog	Occurs only in tanks. The solution oxidizes and an oily brown scum forms on the surface of the solution This layer is picked up by the film	Remove the scum layer with a scoop of filter paper Use a floating lid Remedy: Clean in permanganate solution as detailed in 8 above
30. Rust spots on the film	Metal clips used to hang films up cause rust during drying	Use *stainless* steel, plastic or *clean* wooden clips Remedy: Immerse in 5% solution of oxalic acid (POISONOUS)

Note: The above table should help you to find out the cause of most troubles with negatives. Do not be discouraged, they do not occur very often, and trouble-free processing is easy if you *follow the instructions carefully and use your commonsense and are clean about all your work.* See how many faults in the table are caused by slackness, by dirtiness, by being rough or mishandling the camera and film. Do not *blame the sensitive material* until you are sure you have not made some or several mistakes. The amount of care taken in making and check testing materials is far far greater than you can ever apply to your operations. Gevaert, like all good manufacturers, are grateful to those who genuinely discover and point out defects in their material, but honesty makes them say that over 95% of all the queries dealt with each year reveal faulty storage or handling *after* the product has left the factory – so be warned.

Special notes on faults in plate negatives

★ Abrasion marks

To prevent this trouble plates are packed with pieces of black paper round the two longer edges to keep their emulsion surfaces from touching, so that they cannot rub over each other in transit (see fig. 65 p. 192). It is strongly advised not to remove these separators until the plates are loaded for use. Afterwards, if away from the laboratory, repack the plates separated by black paper sheets. The black wrapping paper used by Gevaert is ideal as it has no action at all on

the emulsion for several weeks at least. Ordinary black paper may. Cut the sheets of paper cleanly so that there are no dust or loose paper fibres. Folds or creases in the paper can also cause trouble by bearing unevenly on the emulsion.

★ Paraffin wax patches

Never let your fingers touch the emulsion side of the film or plate, especially after they have handled the waxed paper which is used to wrap them in. Wax on the emulsion prevents the access of developer to the parts it covers and so causes lighter areas to appear on the negatives.

RETOUCHING THE NEGATIVE

Anyone who wants to become a good retoucher has got to have some aptitude for drawing.

Retouching is carried out on the gelatine layer of the negative using a pencil, brush or knife.

Apparatus

Before we discuss retouching itself let us have a look at the apparatus and materials we need for retouching. First we shall need some kind of support, or retouching desk on which to place the negative to be retouched. Next we need matt varnish – indian ink – lampblack – watercolours, red and black in tubes or blocks – mucilage gum – Grade 00 fine emery cloth to sharpen pencils – black pencils or crayons of various hardnesses for prints – negative storage bags – paint brushes (sable) – knife or scalpel – stumps – conté crayons.

★ The retouching desk

This usually consists of an easel made of three hinged pieces of wood which can be opened up and erected easily. The centre piece carries a sheet of ground glass or opal on which the negative is placed, the base is laid flat on the table. A piece of white paper or card is laid on it to reflect light through the negative so that it can be observed by transmitted light. The negative is usually positioned the correct way up but it is necessary when using the knife, which requires considerable skill and dexterity, to be able to turn the negative round easily and for this a revolving stage is advisable. The top panel acts as a light shield and from it can be hung curtains or a hood of black fabric in the shade of which the retoucher can work.

The black curtain prevents light from behind the retoucher's back causing unwanted reflections on the negative.

A rack or shelf on which the various implements such as pencils, knives and brushes can be kept will also be found to be a great convenience.

Retouching desks of various sizes are on sale. The ground glass or opal should be at least 10 in. square so that whole-plate negatives can be retouched in the vertical or horizontal position. The struts holding the working panel should be strong and rigid so that the hands can rest firmly on the desk and work freely.

★ Magnifying glass

A magnifier of 2½ in. to 3 in. diameter will be very useful at times to examine how a difficult piece of work is going, but should not be used all the time except for retouching very small negatives. In such cases either a wide angle stand magnifier, or a pair of eye glasses held on the head by a frame will be found far less fatiguing to use than a single magnifier in the hand, or in one eye like a watchmaker's glass.

★ Pencils

For negative retouching, pencils of various grades are used, usually HB (medium), 2H and 3H (hard), and B (soft). HB is the most used, others only rarely. Very thin negatives are retouched with hard pencils, a thick negative will need the soft (B) pencil.

★ Brushes

Spotting and removing small lines is done with watercolour and a fine brush. Two small brushes will generally suffice – a No. 0 or 00 and a No. 1 for slightly coarser work. It is best always to use high quality brushes (of sable, or squirrel) because these keep their shape best and will give a fine point, whereas cheap brushes will never permit fine accurate retouching to be done with them.

★ Knife

This is used for removing small black spots and similar defects. It is very similar to a scalpel (in fact a number of suppliers market a detachable scalpel handle and various shapes of blades which are the same pattern as supplied for surgical work).

★ Retouching varnish

The gelatine emulsion layer accepts pencil work with difficulty and as a consequence it is difficult to build up sufficient density over certain areas of the face (e.g. deep wrinkles or creases on the brow, or either side of the nose, etc.) For this reason the gelatine layer is given a coating of matt varnish beforehand. After this treatment it will be found just as easy to pencil on the gelatine as on a piece of paper.

Those who wish to make up their own matt varnish will find a suitable formula in Part V.

Start by rubbing over the gelatine layer of the negative with a clean soft cloth moistened with pure turpentine and rub gently until dry. Then apply a little matt varnish to the areas to be retouched and spread it out with the soft fluffless cloth until it starts to dry.

The application of turpentine beforehand will ensure that the edges of the patches of varnish will not show on subsequent enlargement.

If the first attempt at retouching is unsuccessful then it can be removed by rubbing with a cloth moistened in turpentine, and then the matt varnish reapplied. This can be repeated indefinitely until the precise result aimed at is achieved.

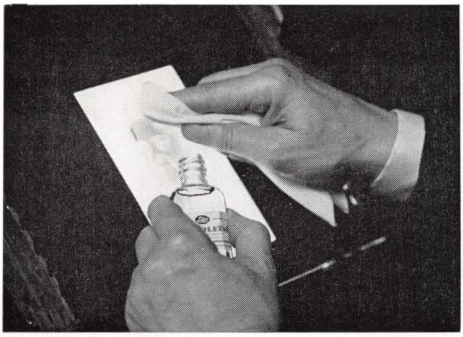


Fig. 67 Start by covering the negative with a thin coating of matt varnish which is applied with a piece of gauze, the corner of which is moistened with a little from a bottle.

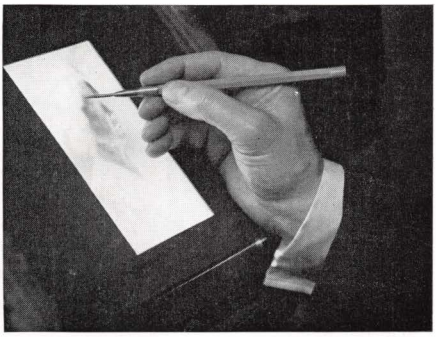


Fig. 68 Pencil retouching: When considerable work is to be done or if you have moist hands be careful to rest the hand on a clean piece of linen or cotton which is not fluffy or a piece of photograph blotting paper.

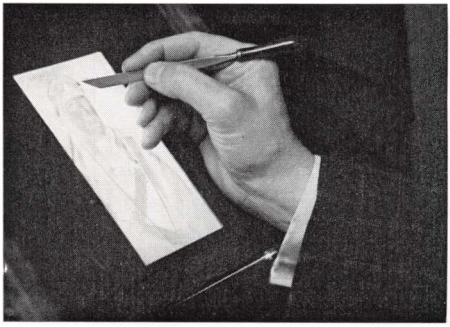


Fig. 69 Knifing or scraping. This operation, which if carried too far is difficult to restore, must be carried out slowly and methodically until exactly the degree of density required is achieved.

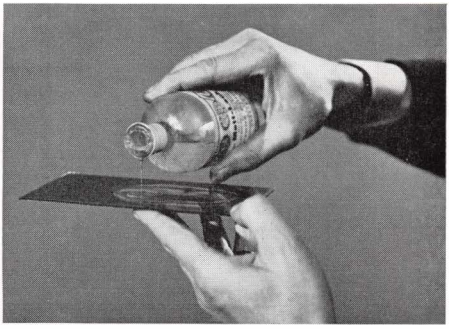


Fig. 70 Varnishing the back. Pour a pool of matt varnish on to the centre, tilt the plate so that it runs to each of the four corners and then drain any excess back into the bottle.

★ Matt varnish

If elaborate background or lighting or cloud effects are to be drawn on the negative a coating of matt varnish is generally given to the back to make drawing easy on it. This coating can also be knifed (and can be coloured to give an overall density to allow variation by knifing). Matt varnish is obtainable from the larger dealers and supply houses. It can be easily made at home from the formula given in Part V.

A number of other methods are also available for bread retouching on the *back* of the negative, although many pictorial workers prefer to make an enlarged *paper* negative for this type of manipulation. Some negative emulsions

are available on a matt surface film base which takes pencil directly. Alternatively the film base can be varnished or roughened by rubbing with metal polish or *fine* abrasive powder or carborundum paste. It if is desired to leave the negative untouched then a piece of thin matt plastic sheet (available in a number of proprietary forms for commercial art work) can be securely taped to the negative and the background drawing carried out on this in whatever way is required.

★ Watercolour

Red or orange watercolour is used to fill in small pinholes and dust spots and scratches as well as to cover over areas of the negative which it is desired to darken down (lighten on the print). This colour is applied to the *glass* side of the negative over the transparent areas, with brush moistened with a little watercolour. The spot of colour is then touched lightly with a finger. If the colour accidentally overlaps the edge of the region where it is required the excess can easily be removed with a piece of wet cloth (or a moistened stump).

In recent years dyes, both of a neutral grey and of an orange-red shade have been used to produce more or less broad effects on negatives. Used in a dilute form they can provide a delicate control over various weak areas of the negative. Their use requires some experience as they are *absorbed* by the gelatine layer rather than overlaying it, and the effect required must be built up very carefully.

Retouching portraits

Retouching comprises work with pencil, spotting and covering up with a brush and pigment, and knifing.

Retouching on the negative should be limited to the correction of small defects such as small spots and skin blemishes. Light red and yellow patches on the skin are rendered lighter on the film and show up as small clearer areas on the negative. Wrinkles and creases cause shadows.

Removal of these patches and shadows is the first concern of retouching. When this has been accomplished you can have a better view of the whole portrait. The most serious defects are generally in the eyes. Then begins the second stage – the correction of larger areas and defects due to lighting and the softening down of any harsh features.

To work with the pencil the negative should be placed on the opal glass of the retouching desk. The pencil used should have a fine point about 1 in. long. A number of pencil manufacturers market holders and long leads without protective wood covering, so that any length can be made to protrude from the holder. To produce a suitable point needs care, a good knife, and a piece of 00 emery or 'crocus' paper. The point is sharpened down until the length required is obtained and then it is rubbed down by rotating it carefully between a folded piece of the emery paper. In this way a fine point can be quickly obtained. Hold the pencil as if you were going to write. It is best to start work at the top left-hand corner (for a right-handed person). Rub the pencil lightly over

the areas which have too little density with a random irregular to-and-fro movement so that these small areas gradually become darker and until they are the same density as their surroundings.

In this way the spots and blemishes are covered over one by one, taking care not to pencil over the edge on to the surrounding area as this will make it too dark, and may make the retouching visible. If the area to be corrected is rather large then avoid working continuously in one location as this may tire the eyes: retouch a little of the area to the right, then a little on the left, and so on.

Removing small blemishes in this way is the first task of retouching. It is not a very difficult task but requires patience and a light hand.

Every worker will adopt a slightly different method of holding the pencil and filling in, but it is a good idea to rest the side of the hand on the easel, on a piece of paper of course, and to work with the side of the pencil point, which must be finished off at a suitable angle. Fine movements and a sufficiently light pressure are then more easily controlled.

Remember also that a harder grade of pencil can be used, especially for thin negatives, where even delicate pencil work runs the risk of detection on the print.

As soon as the whole area is tidied up sufficiently, the second stage can be started, the correction of faults due to lighting such as pronounced wrinkles on the forehead, or under the eyes, multiple highlights or 'catchlights' in the eyes, deep creases either side of the nose and at the corners of the mouth which tend to separate the two halves of the face. This retouching will affect the likeness of the portrait and has to be executed with the greatest care by someone who knows what he is doing. If the face and expression are relaxed then there is not much danger of the characteristic appearance being changed, but if the expression is one of pleasure, inquiry or gravity then the work is considerably more difficult. The retoucher must know which muscles are tensed or relaxed in each expression and how these expressions affect the nose lines, the eyes and the mouth.

The photographer, when he makes the actual camera exposure, will have tried to paint with light; that is, he will have tried to light the features in such a way that only a minimum of hand retouching will be necessary.

Horizontal lines on the forehead do little to express character and they can, therefore, be toned down until they have practically disappeared. Be careful to pencil in the same direction as the creases and not across them.

Vertical lines, however, are very expressive and should not be unduly retouched. But if they are too pronounced as compared with the other features they will of course destroy the equilibrium. It is quite permissible to soften the lines under the eyes, so that the eyes are brought into 'harmony', to the extent that this is possible without destroying what is attractive about them: their life. An eye which is in shadow will not show as well as one lit directly. The retoucher can soon cure this lack of balance. The same remarks apply to the lines at the side of the nose and the mouth.

During the course of retouching it is useful to compare the two halves of the

face by successively covering the two halves with a sheet of paper. The comparison will be of considerable assistance.

Quick careful retouching needs order and method. When starting to practise retouching on a negative, have a straight proof print made. Then retouch the negative until it seems well balanced and take another proof. Continue to retouch until the work seems somewhat overdone and have a third proof print made. Comparison of these three proofs; one unretouched, one correctly, and one over-retouched will show clearly what mistakes to avoid.

★ What can be retouched?

The face and head are made up of a number of areas or planes which are determined by the position and set of the various muscles and the alternation between tension and relaxation caused in them by the feelings and emotions of the model. According to the underlying bony structure one plane will be convex, another concave, one covered with tight skin, another will be more or less hollowed out and yet another curved or protruding.

We will consider for a moment the protruding parts before we answer the question 'What can be retouched?' Since they stand out (from the face) these parts catch the light most strongly. If the main source of light is from above then strong hard shadows are cast. These prominent parts are therefore most important in delineating the areas of the head.

At the top we have two frontal planes on the forehead and just below the two curved eyebrow lines. The two forehead planes and the eyebrows are lit strongly. Between the two from top to bottom runs a line of shadow which is broken up into grooves, especially in old people, and which vary according to the shape of the head and the lighting.

The bridge of the nose is next. If well lit it readily shows separate from the two eyes between which it is placed.

Below this we have the cheek bones which are often accentuated, especially in older or thin-faced people, according to the extent to which the cheeks are hollowed. Finally there is the lower jaw which, because it is in full illumination, shows up strongly against the deep shadow of the neck.

Before being able to improve satisfactorily on the recorded features in a portrait the various 'planes' of the physiognomy must be studied with the closest attention – particularly their relative tones value and their relative size. This preliminary examination will decide what has to be removed or suppressed and what must be merged with adjacent areas by the judicious use of increases or reductions in density.

How to retouch different parts of the face.

1. *The eyes*. A general rule: retouch as little as possible because it is the eyes which impart life and personality to a portrait.

Unskilful lighting can, however, easily throw the balance between the two eyes out so that the portrait gives a false impression of the sitter. In such cases a small amount of retouching can restore the harmony, for example by removing

Wild tulip – Photo: Max Göllner →



or toning down small spots or wrinkles under the eyes. The iris of each eye should contain a clear white spot or 'highlight' since this imparts a lifelike animated appearance. If any eye does not happen to have a 'catchlight' then one can be inserted in the appropriate position by drawing it with a soft (B) pencil.

2. *The forehead.* The brow is of great importance, in that it expresses character and provides valuable evidence of the intellectual capacity of the sitter. The 'set' of the muscles of the scalp are in addition a good indication of the mood of the subject.

The frontal planes are delineated by the highlights which cannot be got rid of nor separated from the roots of the hair with which they are frequently interwoven. With elderly people the wrinkles on the brow form a series of parallel horizontal lines. These can be softened considerably without detracting from the likeness of the portrait. The extent to which they are retouched depends both on the age and the wishes of the sitter.

Vertical lines must, on the contrary, be treated with great care, particularly the two deep lines which commence at the very top of the nose (between the eyes) because these are very expressive of the character of the sitter. Any other vertical lines, whenever they may be on the forehead, may be retouched away completely because they have little or no influence on the expression of personality.

Veins on the forehead and neck are not usually retouched as they are rarely, if ever, visible.

3. *The nose.* If the lighting is satisfactory, only small patches or blemishes on the nose need to be retouched. The nostrils should be left alone.

The two deep folds along each side of the nose should only be toned down if a quiet peaceful impression is aimed at. If the lighting has not been well handled then some lack of balance may result. In a character study these two furrows add considerably to the general expression and should be left just as they are.

4. *The cheeks.* If there are small vertical lines at the edges of the mouth these cannot be retouched, only a slight softening is possible. The lips can be smoothed out a little but be careful not to interfere with the small crease in the under lip.

5. *The chin.* Any lines that are shown too strongly can be toned down, but any dimple or cleft in the chin should be left.

6. *The throat.* The throat can be retouched more or less as you please.

Up to this point we have dealt with negative retouching with *pencil*. There are a number of other and complementary techniques required. The greater part of the work is now accomplished. There may, however, still remain a number of darker areas spoiling the negative and which must be removed. This can be done with the knife.

★ Knifing

Small spots or black lines, an arm that is too fat, unpleasing folds in a garment, stray hairs falling over the face, and many other defects of this kind can be improved or removed with the knife.

The knife, or scalpel, or a cutting nib in a penholder, is held in the hand in the normal writing position. The cutting edge of the blade is passed lightly over the gelatine so that a minute fraction of the silver layer is scraped off and the area to be reduced is slightly and progressively lightened.

Knifing is above all an exercise in patience. Any haste will invariably lead to failure. A reading glass will be found most useful in controlling the progress of the operation. It is most important to avoid making the area being treated lighter than its surroundings, and be careful not to scrape away all the emulsion layer.

The knife must be kept well sharpened, any slight snag or roughness will cause streaks. The gelatine layer should be hard and thoroughly dry, and knifing should be done before varnish is applied.

Knifed areas when viewed by reflected light have a matt appearance. These areas when printed may give a slightly denser result than would appear probable from examination by transmitted light particularly near the clearer areas of the negative. This difficulty can be overcome by varnishing over the knifed area.

Knifing can also be carried out with metal engraving tools and knives of various shapes and sizes, most of which are admirably adapted for the purpose, but what matters most is experience and practice.

★ Working up broad effects on the negative

Something has already been said about balancing the overall tone variation on a negative both with the original lighting and by subsequent pencil work. Shading down on the back of the negative is generally necessary with negatives that are too contrasty, such as is often the case when a single flash source is used on or near the camera with a subject in depth, or the shadow under the chin or a girl's dark hair when these would normally print as deep black devoid of detail, or where on any particular negative similar figures or faces print with different densities. In all these cases of unevenness, which would require manipulation too fine or too tedious to 'shade in' at the time of printing, there are parts of the negative that are too thin with respect to the average density; these let through too much light and this light must be held back by artificial means.

The usual method is to shade the back of the plate with red watercolour paint. Films are mounted on a sheet of glass, so that the shading is out of focus. A fine brush is used to apply it behind areas that are not dense enough. The paint is allowed to partially dry, and then is spread evenly by judicious pressure with a finger. If the colour dries too quickly moisten it by breathing on it, and if you go over the edge with it then it can easily be scraped off or wiped away with a piece of moist cloth or a paper stump.

In recent years some workers have preferred to use a dye solution such as 'new coccine' on the *emulsion* side of the negative. The dye has to be more delicately applied, and used with care on finer areas, although it can always be removed in case of error. Suitably diluted it can produce the most delicate modifications of the original negative densities.

It is also possible by means such as these to throw into greater prominence

highlights that contrast insufficiently with their surroundings by emphasizing them with watercolour.

★ Backgrounds drawn in on the negative

A practical and economic method of adding backgrounds is to draw them in on the back of the plate. Any desired effect may thus be achieved. For those who know how to draw this branch of retouching is very simple. Obviously the drawing must be done on the back of the glass and must, of course, be tonally reversed as a negative. The exposure can be made against a plain background – a dark red for orthochromatic emulsion or a dark green for panchromatic materials. This will then affect the plate very little – giving only a light density. To draw in the background a coating of quick-drying matt varnish is applied to the glass work. Then drawing may commence.

The larger areas should first be covered with stumping graphite, which adheres readily to the varnish. It can be lightly smoothed over or reduced or spread with the finger tip.

Do not take too much powdered graphite at first – it is far easier to darken down than to remove. The finer details are sketched in with a pencil or flexible eraser worked into a point. If the negative is on flat film then back it up with a sheet of glass and carry on exactly as already outlined for a plate.

Flat films are available with matt backing. These lend themselves readily to retouching using graphite powder and a rolled paper stump.

An individual personal style can be imparted to your work by using these methods, for there is practically no limitation to what can be done with them, as even the smallest modifications in the technique employed can produce the most varied results.

★ Local reduction

By 'local reduction' we mean the reduction of relatively small areas of the negative that are too dense. In portrait work it is nearly always the hands that have to be reduced or held back because they are often lit too strongly and print lighter than the face. This defect cannot in all cases be corrected by lighting and the necessary balance has to be restored by local reduction.

Metal polish as used in the house is useful for this purpose, provided it is ammonia or alkali free. The polish must not contain any hard sharp particles, but must be absolutely smooth.

Take a little polish on a pad of cotton wool or a soft cloth and rub down on a waste negative using a rotary movement and light pressure.

As soon as the pad becomes darkened slightly apply it to the negative area to be reduced. The area in question will soon begin to lighten. When the pad will remove no more silver repeat the operation with a fresh pad until the necessary reduction has been achieved.

This technique can be used with success on stray highlights or when a vase or a window or some other light-coloured object obtrudes on the background of a portrait.

Instead of metal polish or plate powder methylated spirits may be used, or

Photo: Kurt Hutton →

even Eau de Cologne, the method of application being identical. After using abrasive polish the negative will look dirty and have a matt appearance. Clean it off with a piece of soft fluffless cloth moistened in petrol, carbon tetrachloride, or trichlorethylene, wiping over the whole of the negative at the same time. After local reduction in this way apply matt varnish. It is obviously better to do this type of reduction work *before* applying any coating to the gelatine-silver layer of the negative.

★ Varnishing

Plate or films should be protected against the effects of humidity and the atmosphere by giving them a light coating of varnish. This will also prevent any pencil retouching being smudged during printing and prevent dust, dirt or grit from harming the negative. Suitable varnishes are sold by the larger suppliers or can be made up to the formula given in Part V.

The applications of an even layer of protective varnish or matt varnish to a negative requires some skill and practice. First remove all dust from the emulsion layer. Hold the plate flat on the left hand, emulsion up. Pour on a generous pool of varnish on to the middle of the plate. Tilt it to cause the varnish to run first to one corner and then to another. As soon as the varnish has spread over the whole negative area hold it vertically with one corner over the mouth of the bottle and drain back all the excess varnish.





Photo: A. Aubrey Bodine

PART THREE

THE POSITIVE

Photographic Papers
Lantern Slides
The Darkroom

PHOTOGRAPHIC PAPERS

You have made your negative. You now want to get everything you can from it because the negative is only a means to an end. There is only one way to do this: to make a positive from it.

Place the negative with its emulsion side in contact with the emulsion side of a piece of photographic paper and hold them together under light even pressure. Expose to light through the negative side: a positive image will be formed on the paper. This image is *latent* and must be treated in a developing solution before it becomes *apparent*. The image that becomes visible then is a *positive*: it will show the tonal values of the subject as they actually are and not inverted as they are in a negative, i.e. the highlights are white and shadows dark grey or black, etc. Great care must be taken with all the operations that go to making a positive. Only someone who has completely mastered the technique and who has discriminating taste will be able to exploit to the full everything in the negative. To start correctly choose the paper that is most suitable for the final effect desired. The variety and selection of Gevaert papers available will make it easy for you to make your choice.

Gevaert papers are esteemed all over the world by practising photographers, amateur and professional. Each particular type will give in its own field the very best result obtainable. The photographer whose choice has fallen on Gevaert papers knows from experience that he has at his disposal for each and every type of work – even for each subject – an appropriate paper. The extremely wide range of kinds of paper and paper surfaces available will always make it easy for him to find one which will do justice to his negative. Of course, he has got to exercise some discrimination in his choice. It is with the aim of helping to make the choice easy that we give here a summary of the properties of each kind of paper and follow this with instructions how to use it. To start with a special chapter is devoted to discussing the fundamental principles which should guide the choice of paper contrast (gradation) and paper surface.

SUMMARY OF THE RANGE OF GEVAERT PAPERS

Photographic papers are divided into three main groups: silver bromide papers, silver chloride papers and chlorobromide papers.

Silver Bromide papers such as 'Gevabrom' are by far the most sensitive to light.

Silver Chloride papers, e.g. 'Ridax', are much less sensitive.

Chlorobromide papers are coated with a mixture of silver chloride and bromide. As the first is more sensitive than the second the emulsion's relative speed will depend upon the proportions of each present.

Types: 'Artona', 'Vittex', 'Gevatone', 'Gevarto'.

In the classification given above only the sensitivity of the different emulsions has been taken into account. Obviously the proper choice of a suitable paper also depends upon other things such as:

1. Gradation (contrast) of the emulsion.
2. Image colour.
3. Surface.
4. Base colour.

Nearly all Gevaert papers are made in several degrees of contrast so that the correct grade can be chosen to match each kind of negative. As far as image colour is concerned (not to be confused with base colour) each paper has its own particular character. There are papers which give blue-black tones, black, warm black and dark brown. Some types such as 'Vittex' give special colours by direct development.

Choice of grade

The plate opposite shows under A, B and C negatives of the same subject that have been underexposed, normally exposed and overexposed respectively.

Figs. I, II and III are prints from these negatives on a single grade of paper: 'Ridax' normal.

B – the normal negative is well detailed in both the highlights (white clothes), the shadows (hair) and the mid-tones (face, doll's dress). The gradation is such that the print looks completely natural as will be seen from II.

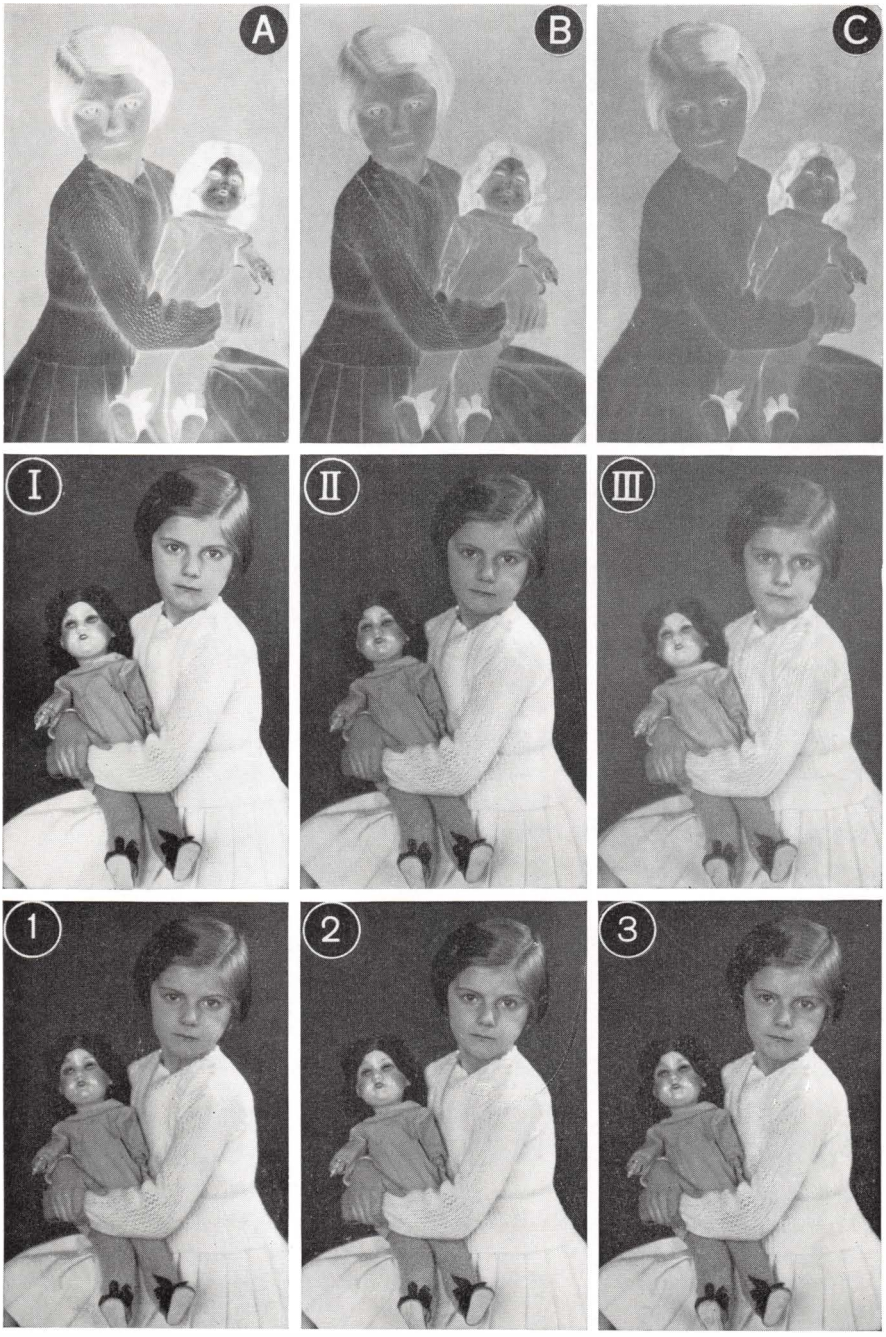
A – the *underexposed* negative lacks details in the shadows. Development has been prolonged and has as a consequence resulted in a gradation which is too hard.

C – the *overexposed* negative is well detailed but is rather flat. It has been removed from the developer too soon. By developing normally this flatness would have been avoided, but in this case the negative would have been too dense – requiring prolonged exposure in contact printing and enlarging.

Figs. 1, 2, 3 show how normal prints can still be made from faulty negatives by the choice of a suitable grade of paper. Fig. 1 is a print from negative A, not on 'Ridax' Normal but on 'Ridax' Soft. It is easy enough to understand why a soft gradation has been chosen. As we have said the prolonged development has given a negative that is too hard. Therefore to get a normal print we must use a paper that has the opposite effect and this is a *soft* paper.

Fig. 2 is the same as II.

Fig. 3 is a print from C but on *hard* paper: the negative in this case is too soft and so we must make use of a hard paper for the same reason which caused us to use soft paper for example 1.


A
B
C
I
II
III
1
2
3

Remember that the examples given above show:

Print a *normal* negative on *normal* paper.
Print a *soft* negative on *hard* paper.
Print a *hard* negative on *soft* paper.

Extra-soft paper is used for very hard negatives and extra-hard and ultra-hard for weak and very soft negatives.

Choice of surface

★ Glossy surfaces

Glossy paper (8 and 47) is recommended whenever it is desired to bring out clearly all the finest detail in the negative. It is used therefore for record, commercial, industrial and scientific photography, and in general in all cases where an absolutely faithful objective rendering of the shape, structure and nature of things themselves are to be shown. Prints for photomechanical reproduction should also be made on glossy paper. In addition it is the best to use for under-exposed negatives.

Glossy papers are the only ones that can be glazed on sheet glass, metal glazing sheets or on the heated drum of a glazing machine (see below).

As far as retouching glossy prints is concerned, remember this can only be done with a brush (or airbrush) and they cannot be knifed unless subsequently varnished.

★ Matt surfaces

Matt surfaces (1 and 5) tend as a rule to cover up fine detail. As a consequence they throw into prominence the effects of masses and emphasize the interplay between highlights and shadows.

Matt prints can easily be retouched by any method; pencil, knifing, tinting. This is one of the reasons why matt paper is often preferred by professional photographers.

Another advantage, useful when used for enlarging miniature negatives, is that the surface texture of matt paper masks graininess better than glossy paper. A deep rich black can be obtained with the 'Artona' K31.

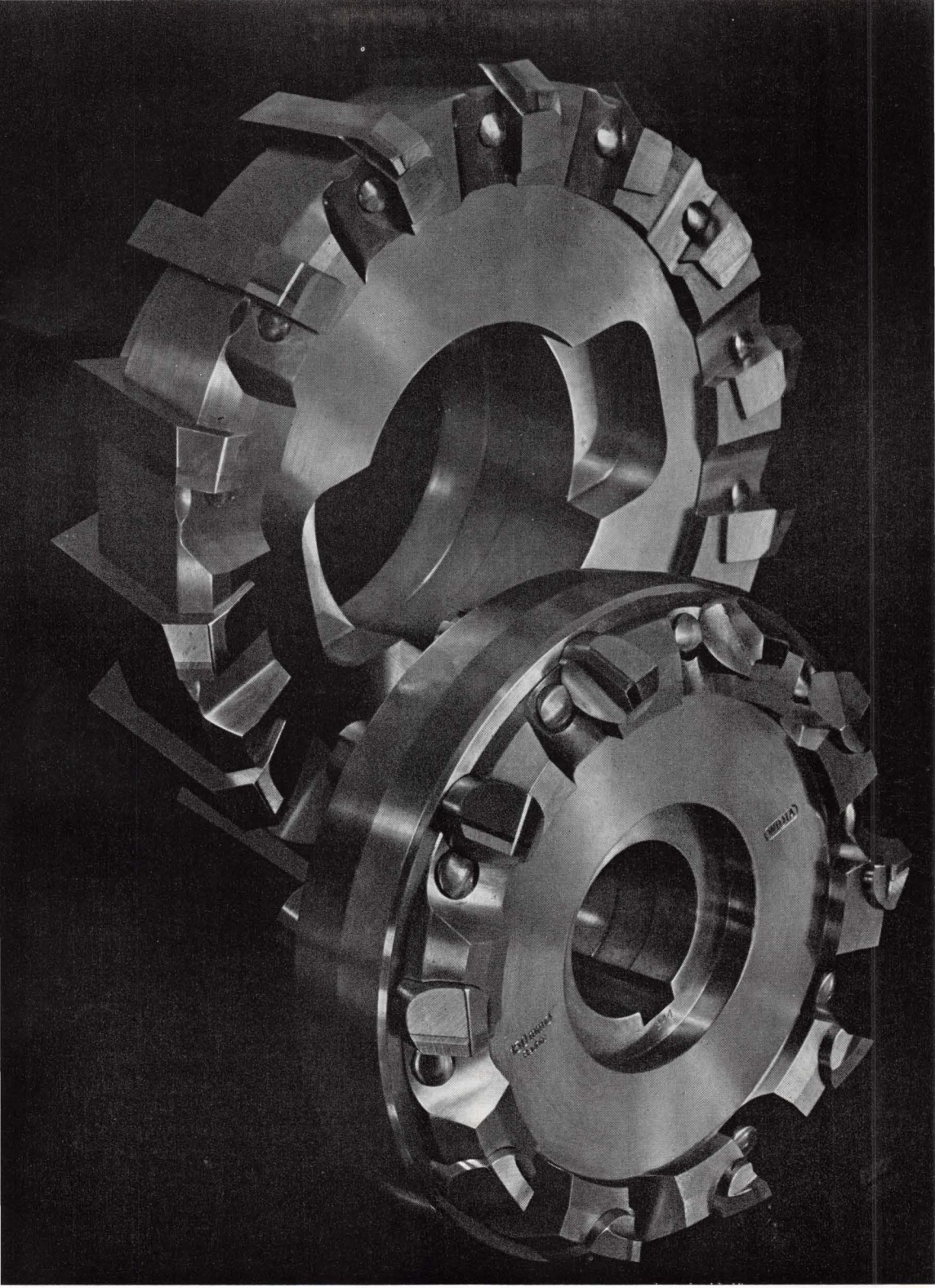
Semi-matt (lustre) and semi-glossy surfaces

Semi-matt and semi-glossy surfaces (3, 7, 34, 36, 44, 45) are intermediate between glossy and pure matt surfaces.

These varieties give prints with fine detail and gradation and are thus very suitable for prints up to half plate in size.

Professional photographs use semi-matt papers for their normal album and postcard sized work and they are favourite surfaces among skilled amateurs for salon work when there is a lot of handwork to be done, especially oil reinforcement or varnishing, etc., etc.

Photo: Adolf Lazi →



Paper base colour

Only very general suggestions can be given as to how to decide on what tint of base to choose.

Ivory and chamois (cream) tints suit portraits very well, giving them a special appearance. As a general rule tinted base papers tend to reduce the visual contrasts and are recommended for making prints and enlargements from negatives and subjects that are too contrasty.

★ List of Gevaert paper surfaces

No.	*Colour*	*Surface*	*Texture*
1 means	White	Matt	Smooth
3	White	Semi-matt	Smooth
5	Cream	Matt	Smooth
7	Cream	Semi-matt	Smooth
8	White	Glossy	
28	White	Supermatt	
29	Cream	Supermatt	
31	Cream	Velvet	
34	White	Royal	Fine Grain
36	White	Semi-matt	Silk-finish
44	White	Semi-glossy	Grained
45	Cream	Semi-glossy	Grained
47	Cream	Glossy	
48	White	Pelligran	
49	Cream	Pelligran	

K before the number means card (doubleweight)

Contrast grades:—

0 for very hard negatives
1 for hard negatives
2 for normal negatives
3 for soft negatives
4 for very soft negatives
5 for extremely soft negatives

When ordering various kinds of paper put the name first, then the weight, and follow this with the surface and then a slanting line and the contrast grade:

e.g. 'Gevarto', normal weight, semi-matt surface, cream shade, hard contrast = 'Gevarto' 7/3

'Gevabrom', card weight, Royal White fine grain soft = 'Gevabrom' K34/1.

★ Notes

Each kind of paper is made in a number of specified surfaces. In deciding which surfaces to provide for each type of paper due account has been taken of the purpose for which the paper is intended.

A paper for amateur contact printing such as 'Ridax' is not marketed in the same series of surfaces as a contact paper intended for the professional photographer such as 'Vittex'. Similarly, enlarging papers such as 'Gevabrom', 'Gevarto' and 'Gevatone' have to satisfy completely different needs compared to a paper which is used solely for contact printing, and they will therefore need different surfaces.



Photo : Papillon



Margit Carlquist – Photo: Rolf Winquist

USING PHOTOGRAPHIC PAPERS

Storage

Gevaert papers will maintain their quality for a long time if kept under good conditions. After taking a sheet out of the envelope return the remainder to the original packing and store this under light pressure in a cool dry place shaded from light and chemical fumes. Never accumulate a hoard of photographic paper in your darkroom.

How to find the emulsion side

The sensitive side of the paper is usually obvious because it is slightly concave and even with matt papers the gelatine coating has more 'sheen' than the paper base. To prevent making any mistakes about this during working, before starting to print count out as many sheets as you need into a slightly larger box (a plate box or an old paper box) taking care to put them all in the same way up. Working in this way will also avoid any risk of abrasion which may cause black marks on the developed image.

Do not touch the emulsion with your fingers, especially if they are wet or contaminated with chemicals. Remember your skin is always slightly moist and quick rinsing never completely removes all traces of chemicals picked up during developing and fixing. Photographers need to be the cleanest of people in their work.

CONTACT PRINTING

Amateurs as a rule use a small contact printing frame to make prints from their negatives. It is very simple to use.

A piece of paper is put into the frame with its emulsion side next to the emulsion side (the matt side) of the negative and with the glossy side of the negative against the glass of the frame. Then the frame is closed and fastened. The frame is loaded, and the other operations which follow are carried out, in a darkroom. When the unused paper has been put back safely into its box the sheet in the frame is then exposed to the direct light from a lamp.

To do this put the frame at a fixed distance from the lamp and switch this on. The time of exposure required will depend on the paper used, the negative density, and the brightness and distance of the light source (fig. 71).

Beginners in particular should try a few test strips first to save wasting whole sheets of paper. Cut a piece into several strips and vary the exposure progressively so as to find the correct time to give. Be careful to expose the test pieces as nearly as possible behind the same part of the negative and see that this has shadows, midtones and highlights in it.

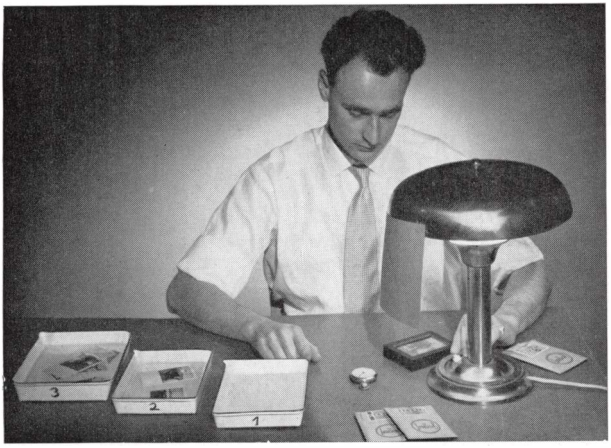


Fig. 71 Contact Printing.

Instead of using several separate strips it is possible to carry out a test on a complete sheet exposing it as follows: Cover the frame with a piece of opaque cardboard and move it in steps across the negative area so that a suitably stepped series of exposures is obtained. It is actually easier to cover up strips after they have been sufficiently exposed (i.e. after 1, 2, 4, 8, 16 seconds, etc.).

The negative and the exposing light

If the light is too strong the prints will be lacking in contrast. If this is the case the printing frame can be covered with one or several sheets of tissue paper – or better still move the frame further away from the light. If on the other hand the prints are too contrasty you must use a brighter light or bring the frame closer to the lamp.

Remember that the intensity of the illumination given by a lamp is inversely proportional to the *square* of the distance from it. The exposure required, therefore, varies in the same way. If, for example, a piece of paper has been exposed to a negative at 10 in. from the lamp it will need at 40 in., that is four times the distance, not four times the exposure but $4 \times 4 = 16$ times. If the correct exposure time at 10 in. was three seconds at 40 in. it will be $3 \times 16 = 48$ seconds. Negatives that have been heavily retouched should be brought reasonably close to the lamp and exposed while the frame is kept moving continuously (with a circular movement) as this will help to hide the handwork on the finished print. It will also reduce definition slightly.

Also, as we have already said, the brightness and the distance of the light influence the print contrast considerably. A bright light or a light close to the frame reduces contrast, a weak light or one at a good distance away increases the contrast.

Tissue paper placed between the light and the frame will, as mentioned above, give more contrast. The paper should not be placed directly on the negative, as this may cause creases on the tissue paper to show as marks on the print, but fastened to the wooden frame with drawing pins so that a space is left between the tissue and the negative. In most cases there will be no need to resort to the use of tissue paper as most Gevaert papers are supplied in a large number of grades of contrast (soft, normal, hard, etc.) so that a paper can easily be chosen to match any given negative.

The weaker parts of a negative can be 'held back' from printing too dark by shading them with a piece of tissue paper cut to shape for the whole of the exposure or by shading them with a piece of card moved over the negative during part of the exposure time. A shading sheet must have an even transmission and must be correctly placed to correspond with the outlines of the negative. It is best stuck by the edges to the *glass* side of a plate negative. Use several sheets of tissue in addition over the whole frame.

Very fine results can be achieved by using a sheet of finely grained ground glass ('acid-etched' or ground with the very finest grade of carborundum powder) which is placed on the negative with its matt side outermost. On this surface all the desired shading is carried out in pencil, or if only partial shading is required in some areas by painting on a light layer of carmine or some other transparent colour such as 'new coccine' according to the supplier's detailed instructions. A coating of matt varnish can also be flowed on to the back of a plate negative and removed locally by knifing where the negative does not need holding back (do not let it get round the edges). Such areas can also be made more transparent by applying glycerine and other suitable oil mixtures to them by brush.

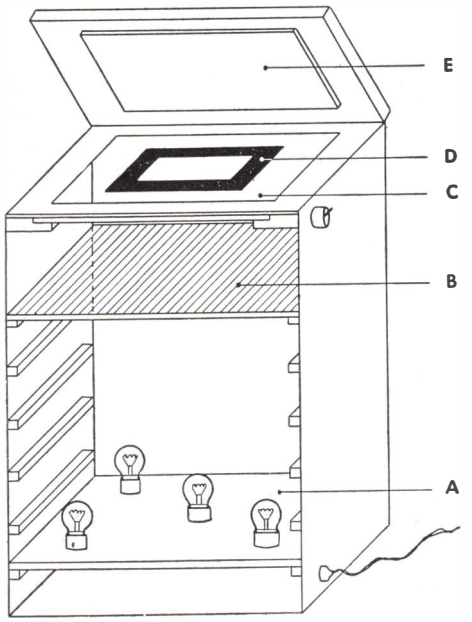


Fig. 72 Contact Printer diagrammatic.

After using any of these varied methods be sure to use several sheets of tissue paper in front of the frame to diffuse the light while exposing. The time of exposure will naturally be increased according to the number of sheets used.

As a rule the best prints are made from negatives which are well detailed and of even exposure and contrast.

Do not leave paper lying about, or handle it unnecessarily near dishes

containing processing solutions. This will prevent accidentally splashing the paper and so causing spots.

Professional photographers and advanced amateurs generally use a *contact printer* with a number of refinements. Fig. 72 shows schematically the principles of such apparatus. One or several filament lamps (A) provide the light for extremely critical sharp work – in science and industry - a small filament lamp at a great distance is used to approximate to a *point* source and are fitted to a shelf which is adjustable so that the distance between them and the opal glass can be varied. The lid of the printer is fitted with a pressure pad (E), some form of adjustable negative mask or a fixed paper mask to correspond to the negative size (D) and a glass plate (C). At some selected distance below this glass is placed the opal glass (B) which diffuses the light.

Contact prints are made in the manner already described. It should be noted that contact printers give prints that, as a rule, are contrasty because of the opal glass which is placed between the negative and the light source.

Be careful with glass negatives in such apparatus. The pressure applied is usually fairly great, and any unwanted grit or folds of paper accidentally trapped between the glass plate and the printer plate will cause the plate to be cracked and ruined irretrievably.

ENLARGING

Cameras using small film sizes have so many advantages that it is not surprising that they are so frequently preferred by amateurs and professionals alike. As a result of this enlarging is resorted to on a scale far greater than it used to be. On the other hand going hand in hand with a reduction in negative size there is an unfortunate tendency towards magnification to sizes which are *too* large.

Gevaert have met the challenge set by these new trends by developing new, finer grained emulsions, which can be enlarged to even greater limits without fear of graininess showing.

To produce good enlargements the technique by which they are made must be thoroughly understood. This chapter goes over the essential theoretical groundwork concerning the different types of equipment and embodies the necessary practical information needed for making satisfactory enlargements.

Methods of enlarging

★ The direct method

Consists of enlarging the negative directly in an enlarger so that a positive enlargement on photographic paper is obtained in one operation and without any intermediate steps.

★ The indirect method

Consists of passing through several intermediate stages before the final enlarged print is obtained. The indirect method can take in the following steps:

1. Printing negative on to plate or film.



Photo : Jean-Loup Sieff

2. Enlargement of this positive on to plate or film.
3. Printing by contact or enlargement on to paper (or lantern slide) of the new negative obtained in 2.

The first method (the direct) is the simplest and also that most favoured by more modern workers. The indirect method allows of infinite manipulation and control and is mainly used by pictorial workers and professionals engaged on very difficult exacting work. It is quite normal in process work for the printing trade.

If enlarged prints are required on slow contact paper or if for example it is necessary to retouch detail on a very small negative, and a larger negative is, therefore, needed for this purpose, the second (indirect) method is then used.

Enlargers

Enlargers fall into three main groups:

1. Condenser enlargers – high brightness – contrasty results.
2. Diffuser enlargers – soft results.
3. Intermediate – condenser – diffuser – reasonably bright – normal results.

★ Condenser enlargers

Fig. 73 shows the principles of this type of apparatus. Light from the lamp (4) which should have a small filament and a clear bulb is collected and converged by the condensers (2), passes through the negative (3) and the enlarging lens (1) and finally falls on the sensitive paper which is held on an easel (7). The enlarger has in addition a lamphouse (8) and as a rule two bellows (5 and 6). To use the apparatus properly, for which purpose these *two* bellows are provided, follow the rule given here: *As the magnification is increased so the lamp should be moved further away from the condenser(s) and vice-versa.*

The rays of light coming from the condenser should come to a focus at the optical centre of the enlarging lens. This condition is essential if an even illumination of the negative and a critically sharp rendering of detail is to be obtained. As the bellows (6) are extended the apex of the luminous cone moves closer to the negative with the result that the bellows (5) have to be closed up.

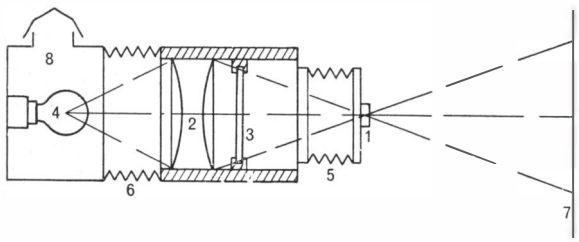


Fig. 73 Horizontal enlarger – condenser illumination.

Enlargements made with this type of apparatus are more contrasty than contact prints made from the same negative on paper of the same contrast grade. This is why:

The luminous flux coming from the condenser traverses the clear parts of the negative with practically no absorption. In contrast the light falling on the darker parts of the negative is not only absorbed according to the amount of blackening (density) but also partly diffused. This causes more light to be lost than is strictly proportional to the density, and it follows that the difference in brightness between two areas of the image projected on the easel is greater than the difference between the corresponding areas of the negative. The enlargement made with this type of condenser enlarger is therefore more contrasty than a proof made on paper of the



Photo : van Houweninge

same contrast grade. This phenomenon was studied originally by Callier and is known as the 'Callier Effect'.

Exposure times with this type of apparatus are relatively short which is a considerable advantage, especially when small negatives which need considerable enlargement are used. Collimated light, however, has the disadvantage of showing up remorselessly every small defect in the negative (scratches, spots, etc.) and any retouching on the negative.

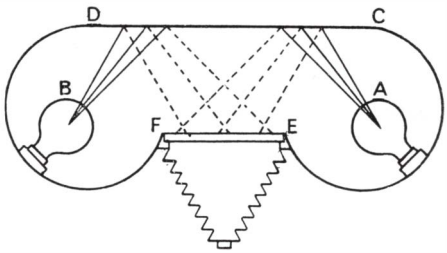


Fig. 74

You must therefore treat negatives that are to be enlarged with great care.

Nearly all modern enlargers are of the vertical kind with the head running up and down on metal tubes. They are easy to set up for centring and exact size, and are much easier to manipulate than horizontal types. They also occupy much less space, shading on the easel is much simplified, and the paper is held without the need for pins, clips or a glass easel plate.

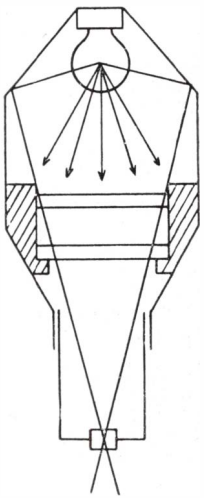
★ Diffuser enlargers

This type gives an image which is nothing like as bright as the condenser type and longer exposure times are thus necessary. It gives enlargements that are softer than would be produced by contact printing the same negative on the same grade of paper.

On the other hand any retouching and small negative defects do not show on the enlargement.

It is not sufficient, as will readily be appreciated, simply to remove the condensers from condenser type enlargers because the direct illumination from an ordinary electric bulb will not give an evenly illuminated negative area.

In some way or other the light falling on the negative to be enlarged has to be evened out. Two methods are possible – either using indirect illumination or by using direct but diffused illumination.


Fig. 75

1. Indirect illumination

Fig. 74 shows diagrammatically how an enlarger using indirect illumination works. Light from lamps A and B is reflected by the surface CD (white or matt silver) towards the negative EF. The light traverses the negative, is collected by the enlarging lens and is then projected on to the easel or paper holder. If lamps A and B are placed so that surface CD is evenly lit and so that no rays can reach the negative EF directly then the rectangle projected on the easel will be illuminated evenly all over, whatever the degree of enlargement used. The need to adjust the lamp position whenever the magnification is changed, as is required with a condenser enlarger, is therefore unnecessary here.

The indirect type of illumination also has the advantage that the graininess is much less apparent.

2. Direct but diffused illumination

Fig. 75 shows the principles of this type of enlarger which has all the advantages of the indirect illumination type and yet makes far more efficient use of the available light. The greater part of the light reaches the negative directly (and not by reflection).

Photo: Yu-Chiu-Cheung →

Between the light source and the negative is placed a diffusing screen (of ground glass or flashed opal glass). The lamp used often has its glass envelope lightly frosted to diffuse the image of the filament and the diffusing screen is often heavier in the centre than at the edges to ensure that the negative is illuminated evenly.

Sometimes the lamphouse of this type of enlarger is fitted with a parabolic mirror behind the lamp to collect and reflect the rest of the light towards the negative.

★ Intermediate types

All those enlargers that have characteristics between the two kinds already discussed are in this group.

Between the lamp and the negative there is a condenser which considerably increases the intensity of illumination and also illuminates the negative evenly. The usual diffusing screen is omitted but the lamp used has itself an opal glass envelope (a number of special types are made with extremely even light distribution) which diffuses the light adequately.

Enlargements made with these enlargers are of practically identical contrast to contact prints made from the same negatives on the same grade of paper.

The intermediate or condenser-diffuser type of enlarger embodies the advantages of both systems. It offers, as compared with the condenser enlarger, the advantage of not accentuating defects and retouching on the negative and as compared with the diffuser enlarger the advantage of higher brightnesses and consequently much shorter print exposure times. Since the luminous source is relatively large it more than fills the enlarging lens so that when this is moved for different scales of enlargement there is no variation in the evenness of negative illumination, so that constant and tedious adjustment of the light source is unnecessary. For this reason alone it is preferred by busy professionals.

This is the only type, therefore, which is actually on the market for amateur use.



Method of work

It is a good idea from the start to adopt a fixed sequence to carry out all work.

★ Preparation

1. Enlarging should be done in a darkroom from which all white light has been carefully excluded. White light leaking in may often not affect silver chloride (contact) papers but will fog the much more sensitive enlarging papers.
2. To start with get ready in the workroom in white light everything you can without letting any light get to the sensitive material. Prepare the solutions, fill the processing dishes and arrange them in the correct order.
3. Then, and only then, switch on the safelight which should be fitted with a yellow, light red, or yellow-green safelight filter according to the type of paper to be used (see the instructions). Having switched off the white light switch on the enlarger lamp.

★ Focusing

Set up the size of enlargement required and focus it. Be very careful to see that the projected image is absolutely sharp. To help get the focus right it is a good idea to use a fogged negative which has been crossed with fine clear scratches with the sharp point of a knife, or make use of one of the enlarging focus finders fitted with a ground glass screen and a magnifier, which are available from all good suppliers.

If a soft enlargement is required with the outlines more or less toned down ('diffusion') proceed as follows: Place over the enlarging lens a diffusion disc or a piece of black tulle or dark fine mesh stocking stuck to a piece of glass for convenience, or stretched tight on a convenient sized filter ring. A piece of ground or lightly frosted glass can alternatively be placed on top of the paper, but in this case the frosting should be relatively even, the thicker the glass the more diffused the image. Another method is to hold a piece of silk over the enlarging paper or on a piece of glass held some way in front of the paper.

It is important to note that the diffusion produced *in the enlarger* has an entirely different character from that produced *in the camera*. Both have their artistic uses. The former, which is favoured by pictorialists such as L. Missonne, spreads light from the shadows into the mid-tones and highlights and gives a heavy sombre effect since it makes for a *darker* tone. Diffusion in the camera which is used in portraiture and by pictorialists of the Mid-European school diffuses light from the highlights into the shadows, thus giving an impression of life and energy since the tone is generally lighter.

Having set the enlarger and focused it, swing the red filter in front of the lens or switch off the enlarger lamp. In any case no white or other actinic light is to be allowed in the workroom.

★ Exposure

Now put in position a piece of enlarging paper and hold it with pins, or with metal or strong black paper strips. It must be quite flat. Then proceed to the

Photo: René-Jacques →


VENTOUX

actual exposure. This is usually determined beforehand by exposing a test strip with steps of different exposure in an area of the image which has shadows, highlights and particularly halftones in it.

Test exposures can be made at a smaller size, and when the correct exposure has been decided the enlarger can be re-set to the larger size finally required. In such a case the exposure that has been determined will need to be proportionately increased for the larger print.

How much? At first sight it is reasonable to say: by the same amount as the image has been enlarged. Thus for an enlargement of two times (linear) the exposure should be according to this $2 \times 2 = 4$ times larger. But this is not correct because it does not take into account the fact that when the lens is focused to give a larger print it is brought nearer the negative and consequently the illumination is increased.

Eder established experimentally the relative exposure times required for different magnifications. These values are given in the following Table.

Relative Exposure Times for Different Degrees of Enlargement.

Magnification (linear)	*Relative Exposure*	*Magnification (linear)*	*Relative Exposure*
1 ×	1	4 ×	6
1½ ×	1½	5 ×	9
2 ×	2¼	6 ×	12
2½ ×	3	8 ×	20
3 ×	4	10 ×	30

For those who prefer a formula the relative exposure is $\propto (1+M)$.[2] Since at 1 : 1 this gives exposure $\propto 4$, at any other scale the exposure as compared to that at 1 : 1 needs to be divided by 4. In the table where $M=8$ (8×) we have relative exposure (as compared to 1 ×) $= \frac{(1+8)^2}{4} = \frac{81}{4} = 20$ times approximately. Any elementary book on optics will give the derivation of this formula.

★ Example

At a magnification of 3 × (linear) the correct exposure is found to be 10 seconds. What exposure will be needed for an enlargement of 8 × (linear)?

★ Answer

The table gives for an enlargement of 3 × (linear) the figure 4 which is equivalent in this case to 10 seconds. For a magnification of 8 × the relative exposure time is 20. Now 20 divided by $4=5$ so that the actual exposure time required for 8 × enlargement is 10 seconds $\times 5 = 50$ seconds.

To avoid the necessity for constant calculations Table D is given in the last part of the book showing the relative exposure required for various degrees of enlargement. You can copy out this table, or better still photograph it and put up a copy alongside your enlarger.

★ Notes

1. Put the enlarger on a firm base and see that it is not subjected to vibrations caused by heavy traffic or from machinery in operation nearby.
2. It is hardly necessary to say that any enlarger can be used to make enlarged copy negatives.

3. If you have a condenser enlarger and want to soften the direct illumination all you have to do is to place a piece of flashed opal glass between the lamp and condenser. The closer the opal is to the condenser the softer the result will be. The exposure time will have to be increased, of course, to compensate for the light absorbed by the opal glass.

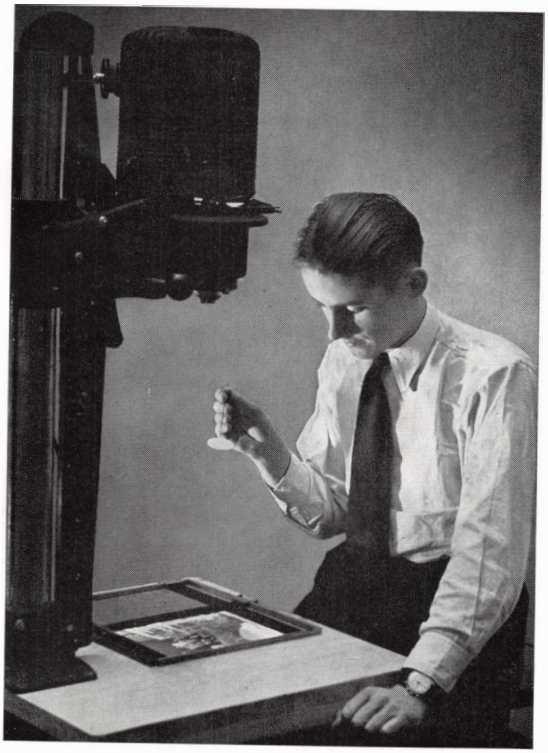


Fig. 76 'Dodging' or 'Shading' to hold back the shadow area from printing too heavily.

4. Do not try to soften or diffuse the outlines of an image by defocusing the lens as this always gives poor results. It is far better to use one of the methods outlined above in 'Focusing'.

5. To keep the whites clean keep the flare light in the enlarger to a minimum. For this reason mask off clear borders round the negative, using strips of black paper if necessary. (Make sure that no light leaks out of the enlarger head, especially if the darkroom walls are painted in a light colour which will reflect stray light. If in doubt carry out a test on a piece of paper.)

6. To 'print' an area or to 'hold back' a part of the picture (e.g. the foreground of a landscape – which generally needs more print exposure than the sky) a small rounded piece of black cardboard is held between the lens and the area to be shaded and kept in continuous circular movement so that it does not cast a sharp shadow (see fig. 76). Better still, a piece of black card cut roughly to the shape of the area to be shaded can be used.

Some people have a whole range of cut-outs on wire for this purpose, some with holes to let the light through. In an emergency the clenched fist can be used. This too must be kept in movement so that the shadow cast has no sharp edges.

7. Avoid enlarging negatives with noticeable grain on to glossy paper. Choose one of the matt grainy surfaces such as K 34 or K 49. For any negatives for which

neither of these surfaces is suitable remember that any of the methods suggested for diffusing the image can also be used to cover up the graininess in a print (see 'Focusing').

Papers recommended for enlarging

The ideal papers to use for enlarging are 'Gevabrom', 'Gevarto' and 'Gevatone'. Perfect enlargements can be made from every sort of negative using any model enlarger. These makes of paper are more convenient for direct work than indirect methods. To make enlarged contact prints from enlarged copy negatives (indirect method) it is better to use 'Artona' or 'Vittex' papers, especially if you want to take advantage of the special range of image colours which these papers will give by direct development.

★ 'Gevabrom' – pure black image tones – various colours by toning

This truly universal paper is supplied in five contrast grades (0 to 4). This range is amply sufficient to give a good print from any negative, in all types of enlargers.

★ 'Gevarto' – warm black image tones

This Gevaert paper for enlarging and contact printing is capable of meeting any demands made of it in practice: it has a fast speed despite the warm-toned image, a great exposure latitude, and is simple to handle; these are its principal properties. 'Gevarto' yields pleasant warm tones by simply developing in a universal MQ developer.

The principal advantage of 'Gevarto' is, however, that the beautiful warm tones are preserved unchanged after drying or hot glazing without preliminary hardening. If the prints are not to be dried by heat 'Gevatone' paper is recommended. Using 'Gevarto' exactly the same image tones can be obtained in enlargements as can be obtained with contact prints. Five contrast grades 0, 1, 2, 3, 4.

★ 'Gevatone' – warm black and dark brown image tones

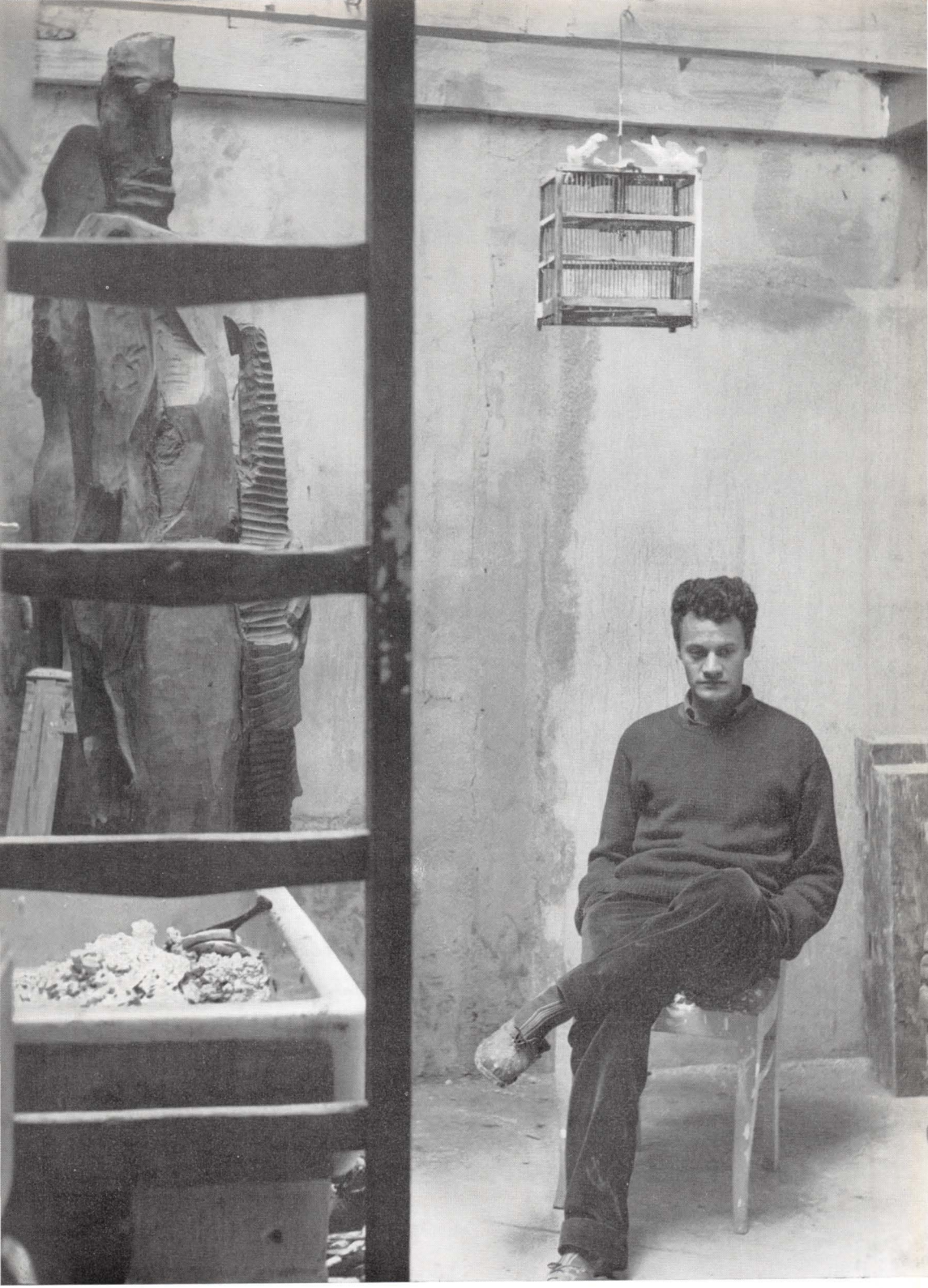
A fast paper giving warm tones. Sold in three contrast grades (1), (2) and (3).

PROCESSING

Temperature of solutions

Try to keep the temperature and the working strength of the developer and fixer at the correct levels. In winter, for instance, if the darkroom is unheated for part of the day (i.e. at night) the solutions will drop in temperature considerably. Make sure they are up to temperature before they are used. Cold developer works slowly and gives soft flat results. Do not forget to warm up fixing baths

Photo: E. van Wijk →



which are made up from hypo (especially desiccated) with cold water, because hypo in dissolving absorbs a lot of heat and cools the solution. It is best, therefore, to dissolve hypo in warm water. On the other hand do not get the solution too warm. Warm developer works rather too fast and gives fogged prints, too warm a fixing bath will give yellowish tones.

The best working temperature for all solutions is 68°F. (20°C.).

Keeping trays clean

The trays used should always be kept spotlessly clean. It is a good idea to clean them from time to time with a 1 : 20 solution of hydrochloric acid, washing off all the acid afterwards in running water.

Instead of hydrochloric acid you can use, if the trays are very dirty, the following tray-cleaning solution:

Water	1,000 c.c.
Potassium bichromate	60 gr.
Sulphuric acid (concentrated) ..	10 c.c.

CAUTION. Always *add* concentrated acids *to water* when diluting them and *not vice versa*. Keep away from fingers, skin and clothes.

This solution has a corrosive action on the skin and should be handled carefully.

Keep special trays for each separate solution. Use glass, porcelain or inert plastic trays or high grade stainless steel. Enamel or papier-mâché trays do not last long and soon harbour impurities.

Development

When the print has been exposed immerse it in the developer so that the whole surface is entirely covered by the solution. The tray should be rocked continuously to ensure even development. The image will start to show at a rate which depends on the type of paper and the developer used. Contact papers after say 15–20 seconds, bromide papers after 30–40 seconds: the time of development is determined by watching the appearance of the image. When the image has reached the depth required, rinse rapidly in water and transfer to the fixing bath.

Contact papers are made so that great variations in printing exposure can be compensated for largely by increasing or curtailing the development, but to get the best results on bromide papers they should be developed for at least two minutes at 68°F. in an MQ developer, and chlorobromides even longer for normal tones. The exposure must be corrected to allow for this.

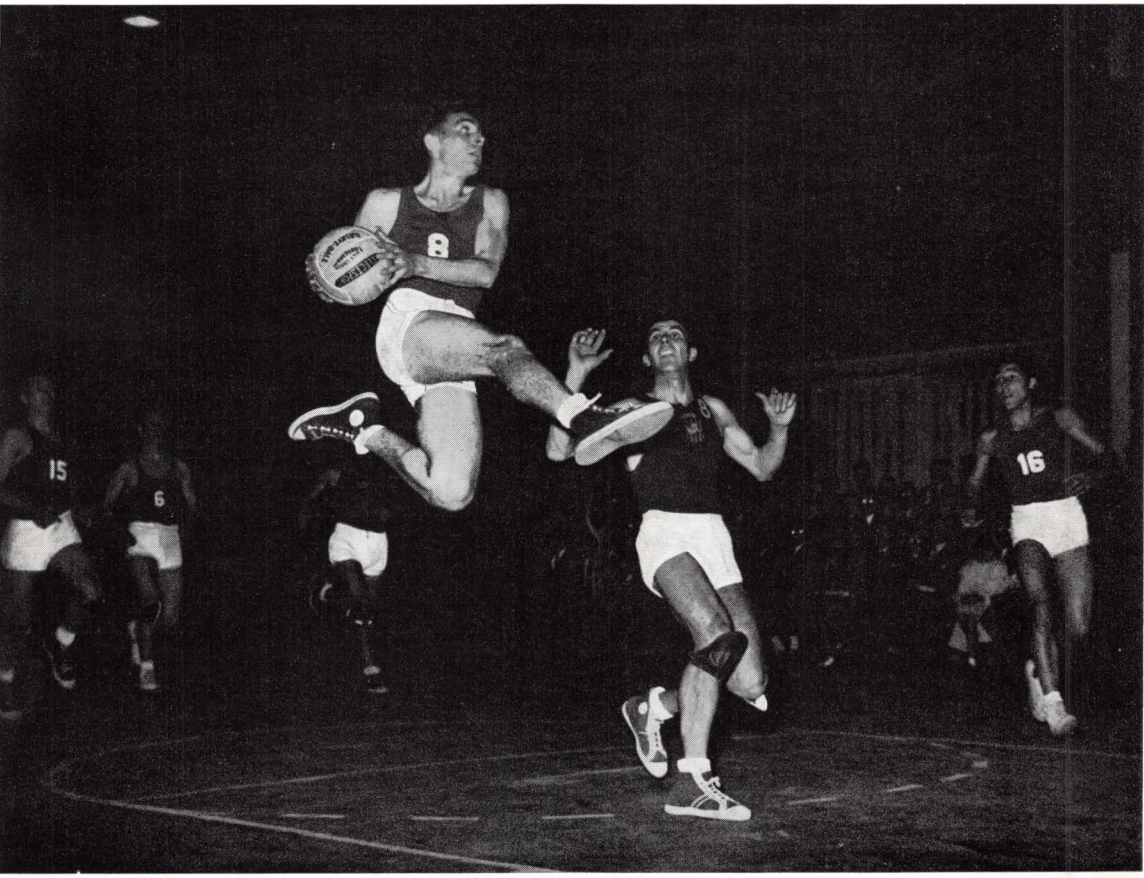
See that all the print is submerged under the hypo fixer as any parts that are left uncovered may stain yellow.

Prints are best passed through a stop bath (see formula G.351) in between developing and fixing. This arrests the developing action and prevents the fixing bath being contaminated and so prevents stain. The print should be drained and rinsed quickly between the stop bath and the fixer.

Photo: Vaerewijk →

Do not use the developer and fixer until they are completely exhausted, renew them from time to time. As a guide one litre (1,000 c.c.) of developer and one litre of fixer are sufficient to process 500 $2\frac{1}{2} \times 3\frac{1}{2}$ prints, or the equivalent area in other sizes. (1 pint = 20 oz. is sufficient for 250 prints). Put the prints carefully and quickly into the developer. If they are just thrown in anyhow there is a danger that air bubbles will be trapped between them and these will prevent the developer reaching the emulsion evenly and will give lighter areas – development marks.

To ensure even development it is a good idea, especially with large prints, to soak the exposed paper in water before developing and to swab it over with a wad of cotton wool to remove any air bubbles on the surface. The print should then be well drained to avoid diluting the developer unnecessarily. With a little practice and the right size of dish and sufficient developer it will soon be found easy enough to develop a print evenly, especially with modern liquid developers



containing a wetting agent. If you arrange your agitation so that a solid sheet of developer sweeps over the paper from side to side this will soon move any air bells.

Fixing

Prints should not be left completely undisturbed in the fixing bath. They should be turned over occasionally. It is best to fix in two successive baths, the second one containing fresh solution. Move the prints one at a time from the first bath to the second. Time required for fixing: 5–10 minutes (card or doubleweight base 10–15 minutes). Do not expose them to white light until they are properly fixed (see the fixing times prescribed). Incompletely fixed prints will stain, or fog all over if exposed to daylight.

★ Tongs, forceps and paddles

For clean working tongs or forceps made of clear plastic strip are strongly advised and can easily be made or bought from any dealer. Prints can be held by the corner with these and hands kept out of the solution. It is a good idea to have differently coloured ones for the stop bath, the fixer, and so on. Instead of forceps a paddle will be found most useful in the fixer and this can be made of plastic or stainless steel. With it the prints are immersed completely by pushing them down with the flat blade of the paddle, and they can be moved round or turned over easily with it even if they are quite large. Keep them clean like the dishes.

Washing

For prints to keep well it is essential, not only that they should be thoroughly fixed, but also that they should be washed sufficiently to completely get rid of all the traces of hypo. If running water is used at least one hour should be allowed for washing prints and the washer should be one of those available which keeps the prints constantly in movement. Alternatively several trays may be used in a cascade arrangement. The prints are moved from one tray to another, starting with the bottom one. The more trays used the more efficient is the use made of the water, and the smaller the quantity of water needed. Cascade washers are also available commercially. If you have no running water you can wash quite efficiently as follows: fill two trays with water. After a preliminary rinse put the prints one at a time into the first tray and when they are all there, transfer them, one at a time (in the same order), into the second tray. Then replace the water in the first tray and transfer them back again singly. Replace the water in the second and continue and so on. It is advantageous if the trays are reasonably large to allow the prints to stay five minutes in each trayful of water. At the end of 12 changes – one hour, the prints should be quite adequately washed. By transferring the prints individually they are prevented from sticking to the bottom of the tray and so not being properly washed.

To check whether prints have been washed sufficiently and are completely

free of all traces of hypo (this takes longer with doubleweight and card bases, but less with waterproof-based paper) take some of the washing water, or allow some to drip off the prints into a measure and add to it several drops of a 1% solution of potassium permanganate. This will turn the water a purple colour. If the colour persists then there is no hypo left. If on the other hand the colour turns pale brown or straw then the prints still have some hypo left in them and should be washed further. Recent work has shown that hypo products can be eliminated more rapidly and washing consequently speeded up by soaking the prints in a 3–5% solution of sodium sulphite. Proprietary mixtures of hypo eliminators are also available.

Drying

Proceed as follows: wipe off the excess water on the prints with blotting paper or a damp sponge (cellulose sponge), or squeegee off with a flat bladed or roller squeegee. Then lay them out face up on sheets of blotting paper in a dry warm, dust free place. Special photo-blotting paper is sold by all the big dealers. Prints can also be dried between two sheets of blotting paper. Some papers, such as 'Gevarto', can be dried by heat.

Glazing

Prints on glossy paper can be glazed by squeegeeing them face down while still wet on to a sheet of plate glass, a ferrotype plate or a chromium plated or polished stainless steel plate. The name ferrotype is properly reserved for a highly polished black enamel surface on steel which was originally used for 'quick-positive' production of beach photography, etc., which went by this name. The plates were subsequently used for glazing, for they gave an admirable finish. In America it is loosely applied to plated or stainless steel glazing plates since neither there nor in Britain can the true glossy black enamel plates be obtained any more.

All photographers know what a fine mirror surface can be obtained by glazing. This gloss is produced by placing the swollen and soft gelatine layer of the paper into close contact with the polished surface of the plate and leaving it there until dry. This contact changes and smooths out the structure of the surface of the gelatine layer which, although it is already smooth, becomes even more highly polished. It is impossible to obtain a really fine glaze on a surface which has any small surface irregularities. A simple example will illustrate this – a mirror which is sandblasted turns completely matt. The sand grains produce numerous minute pits in the glass and these little craters are precisely what turns the polished surface matt.

The explanation of this change is simple. When a small cylindrical beam of light strikes a mirror the greater part of the light is reflected back to the eye as a second narrow cylindrical beam of light. If, however, the mirror struck by the light beam has been roughened by sandblasting the reflected light is dispersed and only a very little reaches the eye. Parts of beams at different angles, which

would normally miss the eye, are now dispersed at angles which strike the eye so the whole surface appears evenly illuminated by diffuse light. This also explains why a piece of glass with a ground or roughened surface has a matt appearance. Photographic paper behaves in the same way: substitute for polished glass glossy paper and for sandblasted glass matt paper and the identical effect will result. This brief explanation will assist in formulating the following rules for achieving a brilliant glaze:

1. Glazing sheets should be perfectly uniform and smooth without the slightest irregularity.
2. The paper surface should be in a soft malleable condition (the gelatine layer should be thoroughly swollen).
3. No foreign body, however small, should be allowed between the glazing sheet and the paper as it will prevent intimate contact between the two surfaces.

★ Some practical hints

Flat chromium-plated sheets or rotating drums are nowadays generally used for glazing, heated by gas or electricity. Sometimes cold glazing on glass is still used (especially for very large prints).

When new, or after replating, plates and drums are sometimes coated with a thin layer of grease. Dust and chemicals will then accumulate and form a crust which is hardened as the heat evaporates the solvents. This makes prints stick at some places.

To remove this thin greasy layer before use wash the plate or drum, first of all with a 3% acetic acid solution, then immediately afterwards with a 5% sodium carbonate, then immediately afterwards wash well in distilled water, then dry off with alcohol and polish to finish with a wad of cotton wool, taking care not to leave any traces of fluff or pieces of loose cotton on the drum.

If *grease* is the trouble this should be removed by swabbing with carbon tetrachloride or better still two or three applications of dichlorethylene,* which is a powerful degreaser and can be bought from any drug-house. Change the part of the clean swab used frequently, a linen or cotton washing-up towel is better than cotton wool as it is less fluffy. Be careful there is not grit as this may cause minute scratches on the drum. Afterwards wash carefully with a pure soap and finish as before.

If, as often happens during long spells of intensive work, a layer of *gelatine* accumulates on the drum then this has to be softened by the application of a weak solution (3–5%) of sodium hypochlorite – a powerful bleaching agent – or rubbing with a cloth, using if necessary a very fine polishing powder, such as a silver polish – or jeweller's rouge. Finish by washing with a very pure soap, plenty of fresh water and continue as above.

Try to avoid trapping bubbles of air between the print and the glazing sheet,

* Do not inhale the vapour, use in a well ventilated place, do not expose near naked flame.

Photo: Boissonas →



which should be perfectly clean, smooth and free from defects. It is best to float on the print in a pool of water, dropping the print from one side and using a flat blade or roller squeegee to put it firmly into contact as the print is lowered before the squeegee. Clean the plates with alcohol and then polish them with a little talc or french chalk, removing all traces before use.

Prints should come away of their own accord when dry and should dry evenly to avoid 'oyster-marks'. If they do not come off easily lift one edge with something thin (not a metal blade as this may scratch the plate) and it should then be easy to detach it from the glazing surface. If glass is being used to glaze on, prints can be prevented from sticking when dry by using a solution of ox-gall (available commercially in several forms). A number of other solutions can now be used instead of this rather unpleasant smelling liquid. The substance in ox-gall that is effective is a chemical substance which has the property of lowering the surface tension and this is precisely the characteristic property of wetting agents such as 'Gevatol'.

It sometimes happens that the surface of a glazed print shows small matt unglazed areas. This can be caused by too high a temperature of the sheet as well as by lack of cleanliness. If this is the case the water evaporates too quickly and unevenly so that in places the paper is lifted from the surface by the force of the vapour formed with detriment to the glaze. If the glazer is too hot and you nevertheless want to continue working most of these matt patches can be prevented from forming by wiping off the surface of the prints with a piece of chamois leather before glazing.

Using 'Gevatol' will help. Leave the paper for two minutes after washing in a 1% solution of 'Gevatol'.

Some papers are more or less hardened in manufacture, and if for any reason they are hardened during processing – if for instance a hardening fixing bath is used because it is the only fixer available – they may become too hard to glaze well. In such cases the pre-bath, which is made up with distilled water to prevent chalky deposits on the plate or drum, may have added to it a small quantity of an alkali such as sodium metaborate (3%) and if oyster marks are causing trouble a small quantity of glycerine may be added to assist in promoting flexibility.

★ Effect of temperature on image tone

Some papers when glazed by heat may have the black tones turned slightly brown – or 'bronzed', i.e. reddened slightly. How can this be prevented? Papers intended to be glazed on modern hot drum continuous machines are generally subjected to a pre-hardening process to prevent the gelatine melting. Unfortunately the hardening agents used have the disadvantage that they discolour the silver image grains at high temperatures. An improved manufacturing process has resulted in this effect being completely eliminated with 'Ridax' paper in particular. For this reason prints made on this paper, whether they are hot or cold glazed, give good deep blacks and clean whites. The same applies to 'Gevarto' – the warm black tone of which is not affected by heat treatment.

Toning

All Gevaert papers are suitable for toning; by this we mean it is possible, by immersing them in a suitably compounded solution, to change the colour of the image. In some cases such a change can give interesting results; for instance a night photograph is much enhanced when toned blue.

You will find set out in Part V of the manual a number of formulae for toning baths together with instructions for their use. The instruction leaflets enclosed with the various papers list the recommended formulae to produce any selected tone. Gevaert Ltd., market a pre-mixed toning solution 'Vittol' which gives excellent sepia tones with 'Vittex' paper.

Before immersing the paper in the toning bath, it is advisable to pre-soak for a few minutes in a solution of 'Gevatol', so that the print surface is uniformly wetted and consequently the action of the toning bath is absolutely uniform over the surface.

Summer Outings — Photo: Asad Ali




BAZAAR

GEVAERT PAPERS

We gave at the beginning of this part some brief details on Gevaert papers. In this chapter the reader will find set out for him all the necessary information about, and detailed instructions for handling, each type of paper.

Where no special instructions are given you should refer to what has already been said in general about fixing, washing and drying.

The recommendations given for safelighting are only correct for normal operating conditions, that is only when half-watt lamps of 15 watts rating are used on mains of their correct rated voltage, at a distance of two feet from the sensitive material being used, and this for a time not (greatly) exceeding the normal processing time.

When indirect illumination is used then it is possible to use a higher wattage bulb or a lighter safelight filter.

The speed of 'Artona' paper is taken as the basic sensitivity. 'Ridax' which has a relative speed of 2 is therefore twice as fast as 'Artona'.

For each paper there are also listed the times of exposure needed for each different contrast grade, relative to the exposure needed for the normal grade. Knowing this ratio, and the exposure time needed to make a print on the normal grade it is possible to calculate easily the correct exposure needed for any other grade of the same paper; all that is needed is to multiply the exposure time for the normal grade by the factor given for the new grade. Obviously the converse is equally applicable when starting from a paper other than the normal grade.

'RIDAX'

Silver Chloride Paper.

Characteristics

'Ridax' is the ideal paper for making contact prints from amateur negatives.

'Ridax' is notable for its simplicity and ease of working, its great latitude in exposure and development, the number of well-balanced contrast grades in which it is supplied, its exceptional resistance to chemical fog and stains, the surprisingly life-like appearance of the pictures and the great number of surfaces and tints available.

It should also be noted that since the characteristic curves of the various grades of contrast converge to practically the same point, a photo-electric cell such as is used in automatic printing machines always gives the correct exposure

← *Photo: Harry Dittmer*

without the necessity of making any allowance for the grade of paper in use. (This, of course, does not preclude the necessity for choosing the grade appropriate to the negative.) 'Ridax' 5, however, is an exception to this rule, as it requires a considerably longer exposure.

In cases where the maximum degree of definition of detail and/or exceptional brightness in the image are the first considerations, such as in prints required for block-making, prints from X-ray films, industrial and scientific photography, etc., glossy white 'Ridax' (8 or K8) is to be preferred because of its long gradation.

★ Image tone: blue-black, black or warm black

★ Speed and gradation

Relative speed factor among Gevaert papers : 2

Contrast grade	0	1	2	3	4	5
Relative exposure times	0·8	1	1	1	1·2	3

Processing

★ Darkroom lighting

Yellow light. Recommended Gevaert safelight:
'Gevinac' safelight L501 (yellow).

★ Exposure

Professionals usually have a contact printer which is specially intended for use with this type of paper.

If you have no contact printer place a sheet of 'Ridax' in a contact printing frame with its sensitive surface in contact with the emulsion side of the negative. This must be done by the light of a yellow safelight.

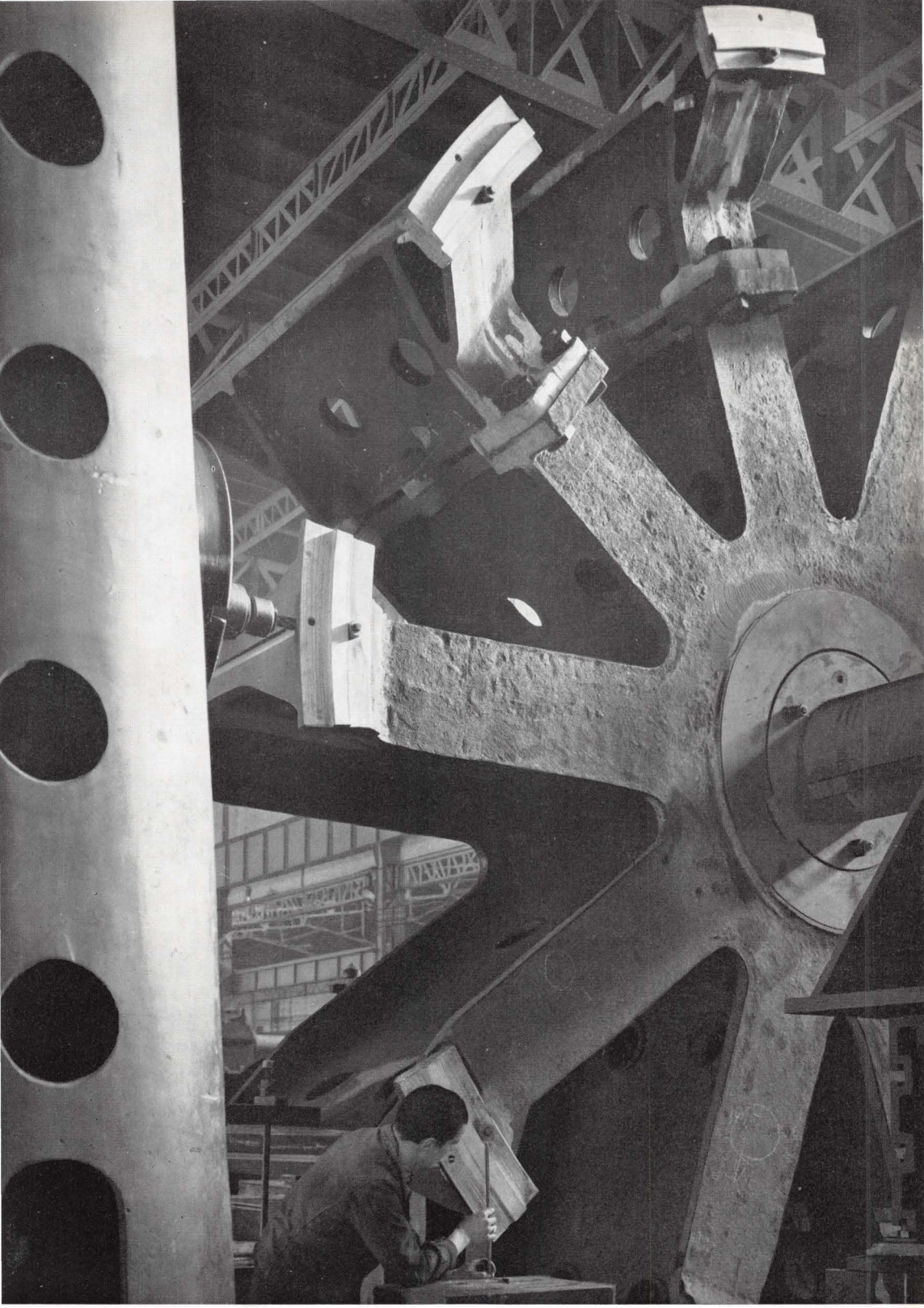
Close the printing frame, place it about a foot away from the white light and expose it for several seconds. To determine the correct exposure time the beginner should make several test exposures (on small strips) and so save wasting several large sheets. Once the correct exposure has been determined it will be the same for all subsequent prints made at the same distance with the same negative and the same light source.

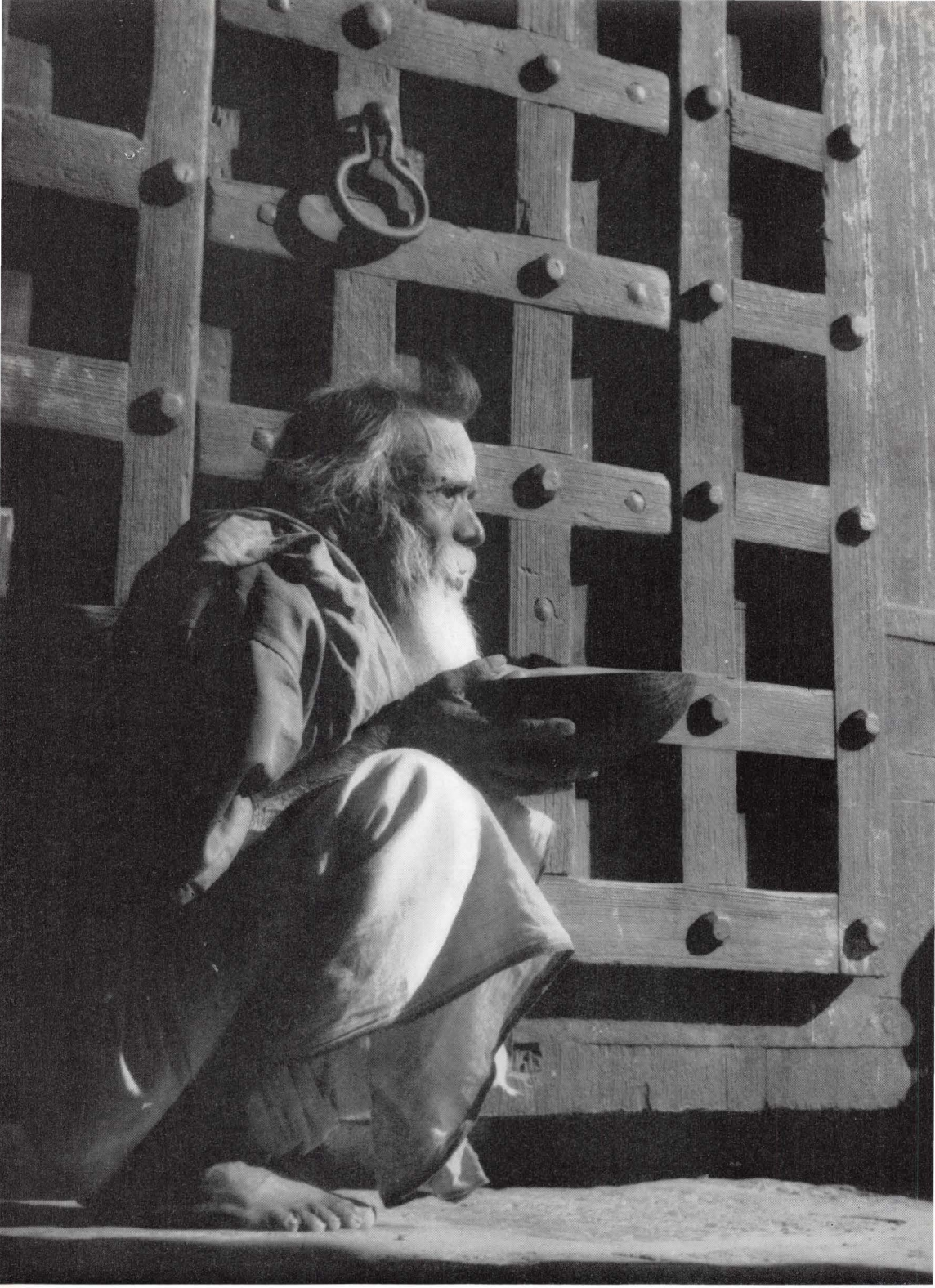
You must take particular care to get the exposure as nearly correct as you can because over-exposure in printing cannot usually be corrected by curtailing development.

The exposure is correct when, in fresh developer of the correct composition at 68°F. (20°C.), the first traces of the image appear in about 15 seconds, a weak image in about 30 seconds and a fully developed image in about 1 minute.

A guide to the correct exposure time required: a normal negative printed on 'Ridax' Normal at one foot from a 40-watt lamp will require about 10 seconds' exposure to give a satisfactory print. As far as other contrast grades are concerned

Photo: H. & C. Lacheroy →





it is a general rule that the exposure time will be the same as the Normal grade, provided the grade of paper chosen is appropriate to each negative; that is to say, for underexposed thin negatives extra-hard or ultra-hard paper, and for hard dense negatives soft and extra-soft paper is chosen. Whenever the negative is both soft and dense the time of exposure on hard contrast papers will need to be considerably increased. No two negatives are ever exactly alike, and one or two test strips will always indicate the correct exposure time.

★ Development

Gevaert 'Metinol U' developer which is available commercially is the best developer for 'Ridax'. This developer gives fine rich blacks. 'Metinol B' should be used if fresh blue-black tones are required.

If you wish to make up your own solutions the correct formula for pure black tones, as given by 'Metinol U', is G.251. For blue-black tones use developer G.252.

Since 'Ridax' paper is quite free of fog or stain at relatively high temperatures, solutions should be kept at about 68°F. (20°C.). Only when all the working conditions are kept constant is it possible to produce consistently good work and to have satisfactory control of the results.

A correctly exposed print needs to be developed for about one minute. If at the end of this time the print is still too light then the exposure has been insufficient. Such variations from the ideal exposure can, however, be corrected to a certain extent by prolonging or curtailing the development.

Developer	*Variety of 'Ridax'*	*Image tone*
'Metinol U'	White base	Neutral black
or formula G.251	Cream base	Warm black
'Metinol B'	White base	Blue-black
or formula G.252		

Recommended time of development: 1 minute at 68°F. (20°C.).

★ Stop bath

After development it is advisable to rinse the prints in water, or better to immerse them for 2 to 3 seconds in stop bath G.351. After this bath rinse the prints thoroughly.

★ Fixing

Fix the prints for 5 to 10 minutes in an acid fixing bath. Recommended fixing solution: Gevaert 'Acidofix' or formula G.301.

★ Washing

One hour in running or frequently changed water.

★ Drying or glazing

Normal. 'Ridax' paper may be dried or glazed hot without previous hardening.

← *Photo: B. Ranganathan*

★ Toning

To obtain other image tones (warm black, blue, blue-green, red) see Part V – 'Toning Bath'.

'ARTONA'

Silver Chlorobromide Paper.

Characteristics

'Artona' is a slow contact printing paper which gives prints of a pronounced warm tone in an ordinary metol-hydroquinone developer. Attractive modulation and great richness of detail are the other characteristic qualities of 'Artona'. The gradation is rather soft, and the prints obtained are remarkably plastic.

Surface K31, which gives 'Artona' its greatest appeal, is a velvet-like surface which is completely matt when viewed from any angle. The relief of the image on 'Artona' K31 far surpasses that which can be obtained with ordinary paper surfaces.

The artistic quality of the prints (hence the name 'Artona') and the simple handling required by this paper have won the universal approval of pictorial photographers.

★ Image tone

By direct development: very warm black to brown-black.
By toning: light sepia.

Photo : Antoine Dries

The picture opposite has been given the title 'Vegetation' by its author. It is a combination of pseudo-solarization (Sabattier effect) and negative printing.

The subject—a spike of oleander—has been set against a white background; to accentuate the upright lines of the subject, a vertical pattern has been projected on to the backing using a spotlight. The subject itself has been lit softly and evenly by the main studio illumination. Here in the words of the photographer are the rest of the details. The picture is taken on sheet film (Gevapan 30 6 × 9 cm.) and for preference three exposures are made so that some variation in the development and subsequent treatment can be tried out. To start with development is in complete darkness for several minutes, thereafter it is watched by the light of a dark green safelight. When those parts of the negative that are not required to be reversed have reached medium density, the pseudo-solarization is started: the negative, turned face upwards in the dish, is exposed to white light at a suitable distance from a source whose brightness should be previously determined by experimental trials. In this particular case the second exposure is for 6 seconds to a 5-watt lamp placed about 40 inches (3 feet approx.) from the film; but these factors are strongly dependent on the precise film and developer being used. The development is continued for a further period of about $\frac{3}{4}$ the duration of the first development. At this stage the negative appears to be uniformly fogged. If this overall density is too great, then the second exposure has been too strong. The attempt can be considered a success if after rinsing and fixing a transparent border can clearly be seen between the highlights and the shadows. From the negative made in this way a positive is made by contact printing and this can then be finally enlarged in the normal way on to a hard gradation white paper to yield the strong contrasts required.





Photo : Van Zeebroeck

★ Speed and gradation

Relative speed factor among Gevaert papers: 1

Contrast grade	1	2	3
Relative exposure times	0·9	1	1

Processing

★ Darkroom lighting

Yellow-green or orange light.

Recommended Gevaert safelight filters: 'Gevinac' safelight X572 (yellow-green) or L552 (orange).

★ Development

Recommended developers	*Dilution**	*Development time at 68°F. (20°C.)*	*Image Tone*
'Metinol U'	Undiluted	1 min.	Very warm black
or formula G.251 (metol-hydroquinone)	With 1 or 2 parts of water	1 min.	Brown-black

* When using diluted developer increase the exposure slightly. For a dilution 1 : 2, the increase of exposure will be about 25%. Note that the dilution of the developer has very little effect on the print contrast.

★ Fixing and washing

See 'Ridax'.

★ Drying

'Artona' is to be dried naturally or between special blotting paper, never on heated glazing plates or drums.

★ Toning

Toner	*Image Tone*
Gevaert 'Vittol' Solution (toning without previous bleaching)	Light sepia

★ Special notes

Surface K31 on 'Artona', the velvet velours, must be handled carefully to avoid abrasion marks. Marks that are not too noticeable can be removed with an india-rubber (or gum art eraser). When the marks have been erased the remaining rubber debris can be removed with a fine soft brush.

'VITTEX'

Chlorobromide Paper.

Characteristics

'Vittex' is a rapid contact printing paper or a relatively slow enlarging paper. It is notable for its fine modulation, its great latitude in exposure and development and its pleasant warm tone (even warmer than that of 'Gevatone' and 'Gevarto') which is obtained by direct development. 'Vittex' is an excellent paper for portraiture and general pictorial photography.

★ Image tone

By direct development: warm black, brown-black, brown, reddish-brown, red.

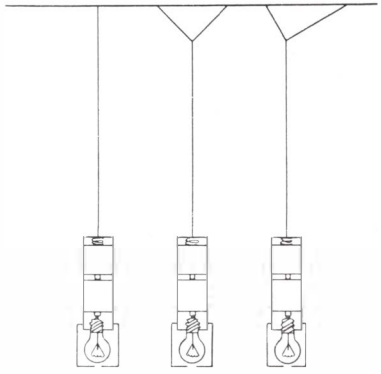
★ Speed and gradation

Relative speed factor among Gevaert papers: 7.

Contrast grade	2	3
Relative exposure times	1	1·3

Harmonic Photogram by Gertrude Fehr →

This type of photogram (painting with light) is made by focusing on the sensitive surface, using a camera, the glowing filaments of a torch bulb (with reflector removed or masked) hung on the end of a fine wire or cord and put into oscillation. To make the light source as small as possible the outside of the glass bulb should be painted over, leaving only a small clear area at the top; or the bulb can be placed behind a small hole so that only the direct light is allowed to pass (*see* fig.). The exposure is of course made in complete darkness. The distance from the lamp to lens: 3 or 4 feet. The camera is laid on its back vertically below the lamp and focused on the filament. The length of string: about 3 feet. The exposure time can be varied but five minutes is suggested as a starting point for experiment. To make more interesting and elaborate patterns the string should be suspended from two points in the shape of a Y, either symmetrically or better still asymmetrically (*see* fig.). The stop to use for 'Gevapan 27' – about *f*/22 for the first trials.



Before making an exposure study the various oscillations which the pendulum will perform and find out how to control it so that it will produce the patterns you require. A reflex camera, or one with a ground glass, is suitable for this purpose, and allows the limits of the swing that can be recorded to be observed beforehand. In making the exposure be careful not to open the shutter (which is set at 'Time') until the pendulum is oscillating regularly. Remember also you can combine several different patterns of the pendulum by successive exposures on the same negative.

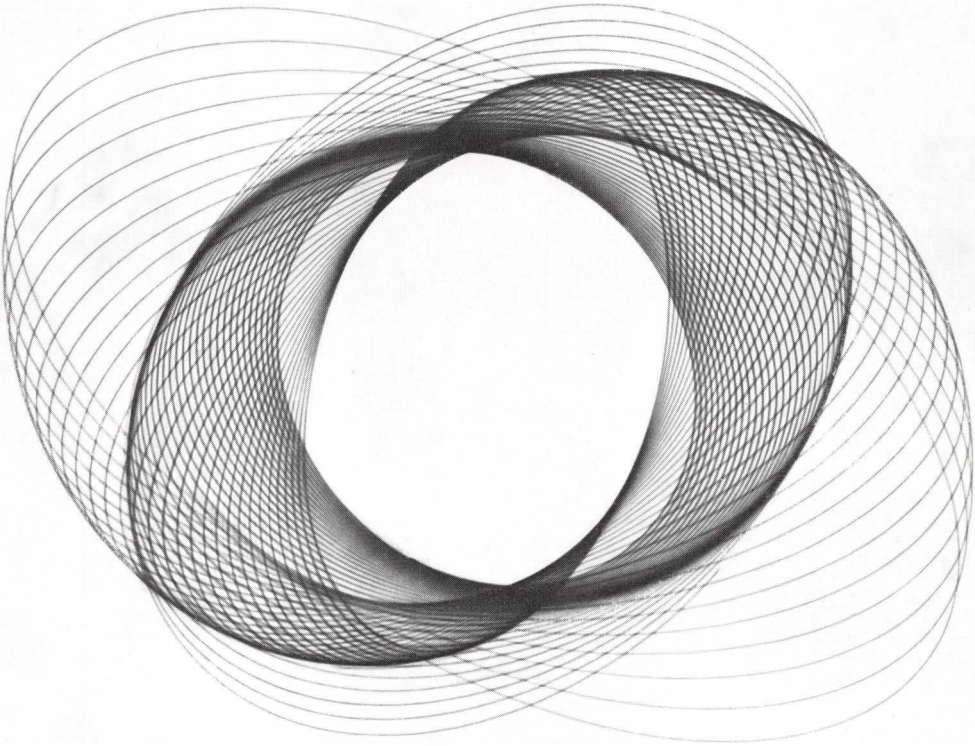




Photo : F. Philippi

Processing

★ Darkroom lighting

Yellow-green or indirect orange light.

Recommended Gevaert safelight filter: 'Gevinac' safelight X572 (yellow-green).

Development

Image tone required	*Recommended Developers*			
	'Metinol U' or G.251		*G.261*	
	Dilution	*Time*	*Dilution*	*Time*
Warm black	None	1–1½		
Very warm black	1–2	1–1½		
Brown-black			None	2–3
Brown			1–2	4–8
Brown-red			3–4	7–15
Red			5–6	15–25

Notes: 'Dilution 1–2' denotes dilution with 1 to 2 parts of water. 'Time' denotes time of development in minutes at 68°F. (20°C.).

The times shown above are given as a basis from which to determine the exact times which will depend on the negative used, the effect required, etc.

When using the 'Metinol U' or G.251 diluted developer, it is necessary to increase the exposure slightly. With developer G.261 the exposure remains the same for all degrees of dilution. Developer G.261 requires considerably more exposure than 'Metinol U' or developer G.251.

★ Fixing and washing

As for 'Ridax'.

★ Drying

Normal.

★ Toning

A very beautiful sepia tone may be obtained by direct toning (without bleaching) in Gevaert 'Vittol' solution.

'GEVARTO'

Chlorobromide Paper.

Characteristics

'Gevarto' is a fast enlarging paper which produces prints of a rich warm black tone when developed in an ordinary metol-hydroquinone developer. The emulsion of 'Gevarto' is specially conditioned to withstand the high tempera-

tures of hot drying and glazing machines, both from the standpoint of image quality and from that of the melting-point of the emulsion (tendency to stick). The application of heat increases the warmth of the tone. Apart from its excellent gradation, 'Gevarto' possesses a wide range of exposure and development latitude which greatly facilitates work with it. The extensive choice of surfaces and contrast grades available allows the best to be made of each negative and gives every print an individual appearance.

'Gevarto' is also suitable for contact printing so that enlargements and contact prints can be matched in tone.

★ Image tone

By development: warm black. Toned: brown, light brown, violet-brown.

★ Speed and gradation

Relative speed factor among Gevaert papers: 30.

Contrast grade	0	1	2	3	4
Relative exposure times	0·8	0·9	1	1·2	1·4

Processing

★ Darkroom lighting

Yellow-green or indirect orange light.

Recommended Gevaert safelight filters: 'Gevinac' safelight X572 (yellow-green).

★ Development

Recommended Developers	*Development time at 68°F. (20°C.)*	*Image Tone*
'Metinol U' or G.251 (M-Q)	1½–2 min.	Warm black

★ Stop bath

After development it is advisable to rinse the prints in water or, better, immerse them for 2 or 3 seconds in stop bath G.351. After this bath rinse the prints thoroughly.

★ Fixing and washing

As for 'Ridax'.

★ Drying or glazing

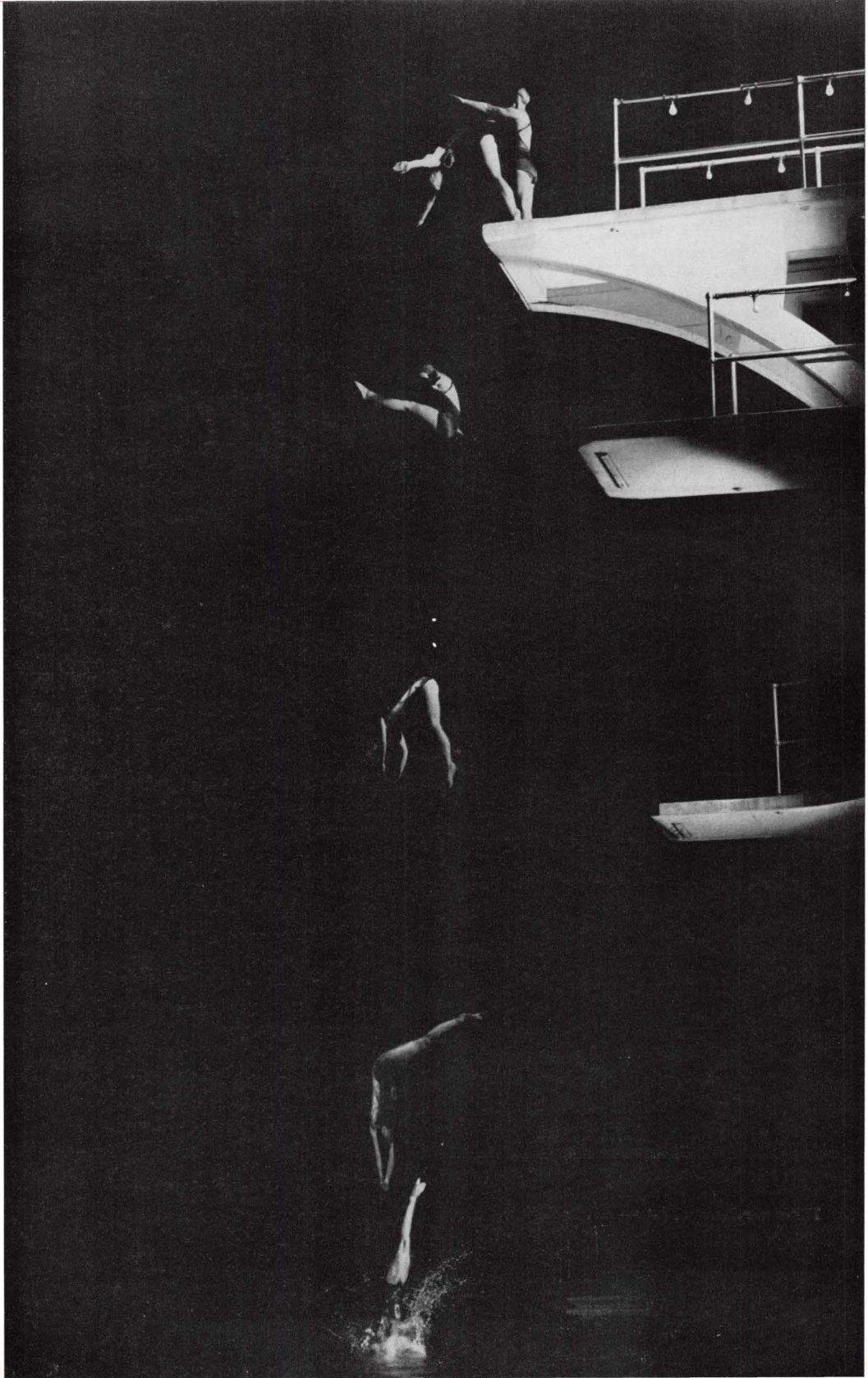
Normal. 'Gevarto' is particularly suitable for drying (or glazing) by heat without previous hardening.

★ Toning

Toner	*Image Tone*
G.420 (no bleaching required)	Brown
G.411	Light brown
'Vittol' (no bleaching required)	Violet-brown



The actress Suzanne Flon — Photo: Etienne Bertrand Weill



'GEVATONE'

Chlorobromide Paper.

Characteristics

'Gevatone' is a fast enlarging paper which gives very warm black tones in an ordinary metol-hydroquinone developer and brown-black tones in a hydroquinone developer. The tones obtained with 'Gevatone' are even warmer than those on 'Gevarto'.

'Gevatone' is also notable for its adaptability to all sorts of negatives, owing to its rich gradation, its extensive range of surfaces and contrast grades and to its great latitude in exposure and development. By carefully balancing two apparently contradictory characteristics – high sensitivity and warm tone – 'Gevatone' has been made specially suitable for the professional photographer.

Prints on 'Gevatone' are prized also for their open shadow gradation, clean highlights and faithful rendering of all the details in the negative.

★ Image tone

By direct development: warm black, brown-black. Toned: light brown, brown.

★ Speed and gradation

Relative speed among Gevaert papers: 30

Contrast grade	1	2	3
Relative exposure times	1	1	1·4

Processing

★ Darkroom lighting

Yellow-green or indirect orange light.

Recommended Gevaert safelight filters: 'Gevinac' safelight X572 (yellow-green).

★ Development

Recommended Developers	*Development time at 68°F. (20°C.)*	*Image Tone*
'Metinol U' or formula G.251 (MQ)	1–1½ min.	Warm black

★ Stop bath

After development it is advisable to rinse the prints in water or, better, to immerse them for 2 or 3 seconds in stop bath G.351. After this bath rinse the prints thoroughly.

★ Fixing and washing

As for 'Ridax'.

← *Edna Childs, British women's champion, diving from a 35 foot board – Photo: Roger Wood*

★ Drying and glazing

Normal. If it is desired to dry 'Gevatone' on heated drying machines or glazers, a hardening fixing bath must be used. As a general practice use 'Gevarto' for this type of work.

★ Toning

Toner	*Image Tone*
G.420 (no bleaching required)	Light brown
G.411	Yellow-brown
'Vittol' (no bleaching required)	Brown

'GEVABROM'

Silver Bromide Paper.

Characteristics

'Gevabrom' is a rapid enlarging paper giving prints of a rich neutral black tone, vigorous appearance and delicate rendering of detail.

It is supplied in a great number of surfaces and grades of contrast, which enables the correct paper to be selected for every type of negative. For this reason, 'Gevabrom' is considered to be the universal enlarging paper. While it is highly valued by the pictorial photographer it is at the same time an excellent paper for all kinds of amateur work.

Surfaces 8 and K8, which give particularly brilliant results, are recommended for such subjects as commercial and scientific photography, enlargements intended for blockmaking, etc.

★ Image tone

Neutral black by direct development. Toned: brown.

★ Speed and gradation

Relative speed among Gevaert papers: 60

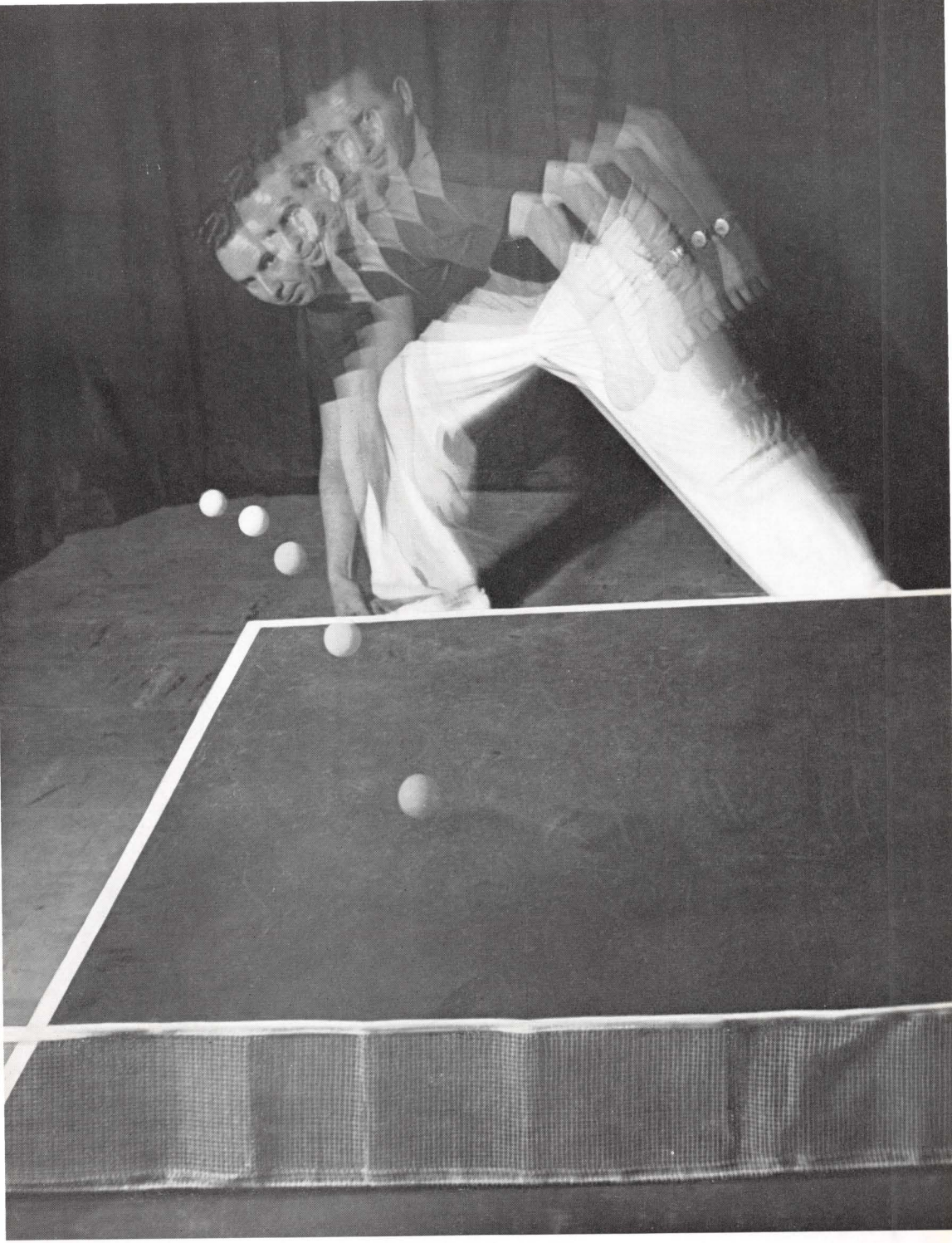
Contrast grade	0	1	2	3	4
Relative exposure times	0·7	0·8	1	1·5	2

Photo: Roger Wood

The picture of player Stephen Boros has been made by stroboscopic flash. A stroboscopic flashlight gives a series of very short flashes at regular, and pre-selected, intervals. The short duration (about 15 micro-seconds) freezes the movement, giving a number of successive pictures on the same piece of film. This method gives a very good indication of the way the movements succeed each other.

A moderate speed material was used for this shot, so that the overall illumination does not register and interfere with the flash pictures, because it is so much weaker than the stroboflashlight (5.100 joules), which can be exposed at f/11.

This technique can be used for all types of rapid movement: sports, working, rapidly moving machine parts, etc., etc.





Processing

★ Darkroom lighting

Yellow-green light or indirect orange light.

Recommended Gavaert safelight filters: 'Gevinac' safelight X572 (yellow-green).

★ Development

Recommended developers	*Development time at 68°F. (20°C.)*	*Image Tone*
'Metinol U' or formula G.251 (metol-hydroquinone)	1½–2 mins.	Neutral black

★ Stop bath

After development it is advisable to rinse the prints in water or, better, to immerse them for 2 or 3 seconds in stop bath G.351. After this bath rinse the prints thoroughly.

★ Fixing and washing

As for 'Ridax'.

★ Drying and glazing

Normal 'Gevabrom' paper may be dried or glazed (glossy papers) by heat without previous hardening.

★ Toning

Toning in G.411 gives a very pleasant brown tone.

FAULTS IN PRINTS

General defects

1. Flat weak prints

Causes:

A Paper too soft for negative.
B Developer too diluted or exhausted.
C Exposure insufficient, or development cut short.
D Developer made up incorrectly or wrong developer used.

2. Prints too contrasty, details on both shadows and highlights missing, 'Soot-and-white-wash appearance'

Causes:

A Paper too hard for negative.
B Print under-exposed and over-developed.
C Developer too vigorous, too much hydroquinone in relation to metol.

← *Photo: Zingher*

3. General fog and greyness

Causes:

A Light fog: e.g. from unsafe darkroom safelight, or from white light leaking into darkroom (round door edges, etc.).
B Paper stored in humid or hot conditions, or accessible to chemical fumes.
C Prolonged development, or developer too warm.
D Developer with too much carbonate (alkali) or too little potassium bromide.
E Paper too old.

4. Yellow fog

Causes:

A Prolonged development, developer too warm or exhausted.
B Prints not rinsed or immersed in stop bath (G.351 or G.352) after development.
C Developer contaminated with hypo (separate trays not kept always specifically for developer, fixer, etc.).

Photo: R. Sinclair





Fig. 78 Some frequent print faults.

1. For comparison, a correctly processed print.
2. Irregular development.
3. Part of print stuck to another during development.
4. Negative reversed during printing (shiny side to paper).
5. Fingermarks, with hypo, after exposure.
6. Splashes of hypo on undeveloped print.

5. Patchiness, spots and marks

Causes:

A Print not completely covered by developer.
B Print over-exposed and development curtailed.
C Abrasion, one print against another, undue friction or pressure (before development). Not generally prevalent with glossy surfaced papers.

Remedy for C

Remove paper *carefully* from its packing. If the marks still persist rub the developed print lightly with a piece of cotton wool dipped in alcohol or better still the following solution:

Water	8 cc.
Alcohol	6 cc.
Ammonium Hydroxide	2 drops

If the marks are rather heavy try a very dilute solution of potassium iodide made up as follows:

Water	100 cc.
Potassium Iodide	10 g.
Iodine (resublimed)	1 g.

This stock solution keeps well in a brown bottle. For use dilute 1 part of stock solution with 100 parts of water. The paper will turn light blue in this solution. A fresh fixing bath will disperse this colour and remove the silver marks at the same time.

6. Greenish tones

Causes:

A Insufficient development.
B Excess potassium bromide in developer.

7. White spots and marks

Causes:

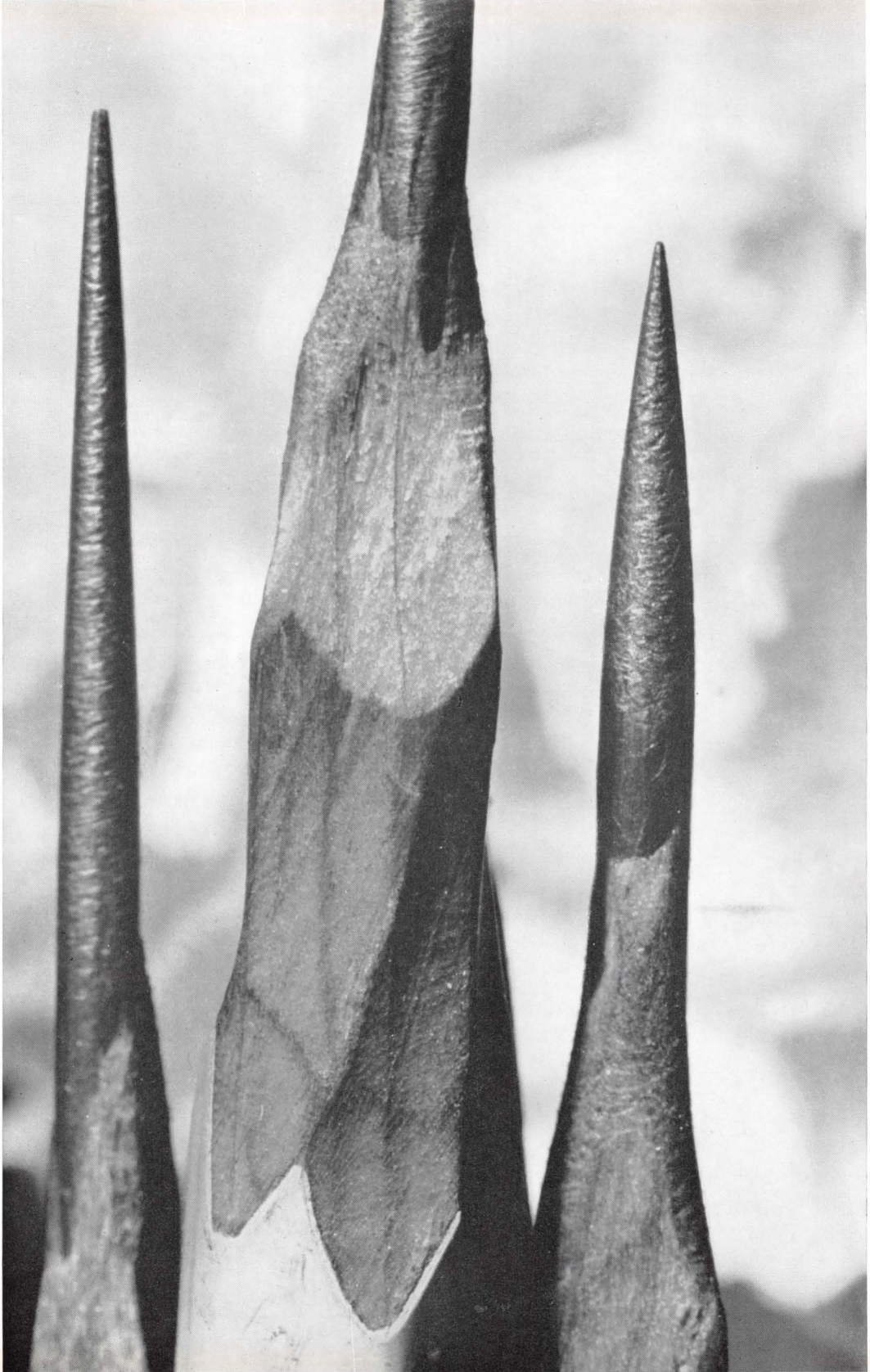
A Dust, dirt, or foreign bodies (paper debris) on the negative (or paper) during printing.
B Air bells on paper surface during development when print not kept in movement, particularly to start with. This defect can also be caused by putting print in developer face down.
C Splashes of hypo on print before development.
D Air bells on print in fixer (yellow or reddish patches).

Remedy:

White spots can be easily 'spotted out' using a little watercolour put on with a fine sable or squirrel brush (nearly dry), or a fine pointed soft lead pencil.

Photo: Paul Facchetti →





8. Black areas, patches and spots

Causes:

A Undissolved particles of chemicals in the developer. Always dissolve chemicals completely one by one, in the correct order. Finally filter solution before use.

B Splashes of developer, reducer or developing agents, etc., on the emulsion.

C Touching the emulsion before development with fingers contaminated with chemicals.

D Holding the print in hot hands to examine it during development.

9. Red or yellow patches and spots

Causes:

A Air bells in the fixing bath; keep the prints in movement with the image face down, especially to start with.

B Unfixed areas of image: after development prints have not been rinsed or immersed in a stop bath; prints have not been kept moving in fixing bath or, if large quantities have been handled, they have stuck together.

C Impurities, especially vegetable matter, in the wash water. This can only be removed by adequate filtering, and in difficult locations where water is particularly bad in dry weather when reservoirs are low, activated carbon filters may be necessary to remove colouration. Do not in such circumstances use a hardening bath containing *alum* as this mordants the vegetable dye. Cut washing to the minimum time necessary.

D Small yellow spots, sometimes reddish-brown, may be caused by rust from the main water supply or from a defective cold water tank, or from chipped enamelled iron dishes. This can easily be identified by the blue colouration produced with ferricyanide. Filtering and clean dishes usually prevent such defects.

10. Image fades on drying

Cause:

Print over-exposed and underdeveloped so that the silver bromide layer has only been darkened on the outside.

Remedy:

Such a print can be preserved by varnishing the emulsion with a celluloid varnish (*very* inflammable) (see the formula given in Part V 'Useful hints and recipes'). To reduce the glossy finish dilute varnish with any acetate. Weak shadows can be improved by waxing the print with a suitable wax furniture polish or with a solution of wax in ether. This strengthens the shadows and makes them more transparent.

11. Irregular concentric rings, not on the negative, but very noticeable on prints (Newton's rings)

Cause:

If the negative is not pressed evenly flat against the glass of the pressure plate of the contact printer or negative holder, but only touches in one or a few

← *Photo: Van Obbergen*

places concentric rings (which are coloured in white light) will show. They are known as Newton's rings. This trouble often occurs when contact printing large negatives and enlarging small ones. The rings show clearly on prints and are most undesirable.

Remedy:

Place a sheet of cellophane between the glass pressure plate and the base (shiny) side of the negative. Use a glassless holder for miniature negatives.

This effect is often caused by excessive pressure. With large negatives a matt base will remove the trouble or make it much less apparent as it only shows strongly with collimated light or condenser illumination. Some modern enlargers are provided with finely etched condensers to prevent this contact trouble. Also, this effect is prevalent in binding slides and diapositives on glass and needs similar care to be avoided.

12. Blisters on the emulsion during fixing or washing

Causes:

A Great variations in temperature between developing and fixing or between fixing and initial washing water. Particularly liable to happen when fixer is prepared (from anhydrous salt) in cold water and used just as it is (without allowing it to warm up).

B Fixer too concentrated.

C Water from tap impinging directly on to film.

D Folds or creases in the paper.

Remedies:

A The different solutions should be near enough at the same temperature (room temperature – 68°F. (20°C.)). Harden the prints after fixing, or fix in an acid hardening fixing bath in a weak alum or formalin solution, or add a little fixer to the first wash water. Do not mix fixer with cold water. Dissolve chemicals in warm water and then let them reach working temperature before use. If the wash water is very cold place prints first in a tray of clean water warmed to 68°F. (20°C.) and then allow the cold water to trickle in *very slowly* so that the wash water temperature is reduced *very slowly* to the temperature of the cold supply. Then proceed to wash in tap water, remembering washing takes longer at low temperatures.

B Use fixer at correct strength.

C Fit a sprinkler attachment to tap or wash in successive changes of water in a tray.

D Be careful handling the paper. Soak the blistered parts in alcohol and then pierce the base with a needle or pin behind each blister. Press back into place gently between clean photographic blotting paper.

Photo: Astrid Gillsäter →

Faults in toning prints

★ Sepia toning

13. Prints toned in sulphide are too yellow

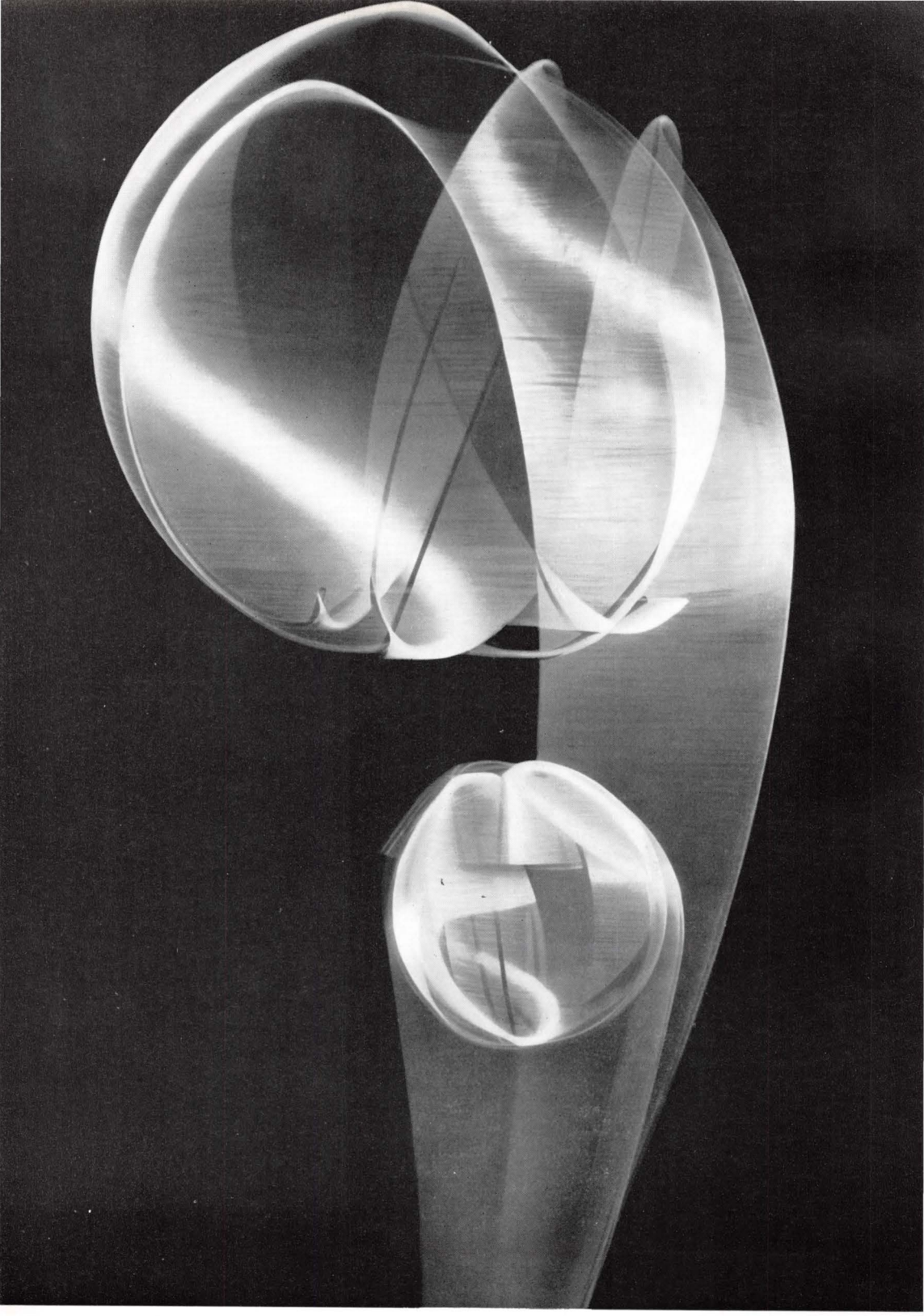
Causes:

A Incomplete development or developer too weak.
B Sulphide solution exhausted.

14. Prints toned in sulphide are too cold

Developer too strong or development carried too far.





15. The bleached print will not tone (see above also).

In some cases the image may completely disappear, is not restored in the toning bath and cannot be redeveloped, or the print may tone only faintly but returns to normal strength if redeveloped.

Causes:

Fixer (hypo) has not been completely eliminated, fixing was incomplete, or the sodium sulphide toning bath was oxidized or contaminated (the sodium sulphide itself may have become impure during storage). Make sure that fixing is thorough, and that washing is also carried out properly.

Remedy:

A print with this defect can still be rescued by bleaching it in a bichromate bleach and subsequently redeveloping in a concentrated *print* developer.

16. Blue spots on sulphide prints

Cause:

Blue spots are caused by iron or rust particles in the wash water which become embedded in the emulsion and are converted to prussian blue in the bleach.

Remedy:

To remove swab locally with cotton wool dipped in equal parts of hydrochloric acid and water (*be careful* with the concentrated acid. Keep away from skin and the eyes). As soon as the spot has disappeared wipe off excess acid with cotton wool and re-wash the print thoroughly.

17. Blisters in the emulsion layer

Cause:

Sulphide toning bath too concentrated.

Remedy:

Dilute to correct strength. Harden before fixing.

★ Toning with copper

18. After a while the prints show rainbow colours

Cause:

Inadequate washing after toning.

Remedy:

Rub the emulsion layer with fixer, or with wax polish.

★ Blue toning

19. A *Irregular toning, toning with difficulty*
B *Prints too dark after toning*

Remedy:

A Use fresh solutions, made up from fresh chemicals.

B Do not prolong the toning unduly. Prints that are too dark can be cleared in weakly alkaline water (by addition of several drops of ammonia or a small amount of sodium carbonate).

← *Photo: Pim van Os*



★ Green toning

20. A *Unpleasant shade*
B *Patchy toning*
C *Stained highlights*

Remedy:

A Use fresh pure chemicals for making up solutions.
B Wash thoroughly in clean dishes.
C Wash well after fixing. The whites can be cleared in a 4% solution of ammonium thiocyanate. Only choose prints with completely clear whites for green toning.

★ Special notice

Defects for which no cause can be found should be brought to the attention of Gevaert. Attach to your letter the following items, each with your name on the back:

1. A print showing the defect in question.
2. Several prints that have been exposed but *not* developed.
3. Several unexposed pieces of the same paper, with the emulsion number written on them (from the outside of the packet).

All carefully wrapped up to *exclude* light and properly marked to avoid accidental opening in white light.

Gevaert undertake to let you know the cause of the trouble and the way to avoid it in future.

← *Photo: Kees Hana*
Macrophotograph of a passion flower.

Macrophotography is the name given to the reproduction by photography of living things or objects at their normal size or somewhat enlarged so that the negative itself carries an image which is at least life-sized. Such photographs generally require equipment made or adapted specially for the purpose. For some types of subject close-up lenses are all that will be needed, but they will result in unpleasant distortions when used for three-dimensional solid objects. For photographs under natural conditions telephoto lenses are generally used. There are available for most modern miniature cameras a wide selection of accessories for macrophotography.

An old bellows camera in good shape can, however, yield excellent results. The lens is replaced by another of shorter focal length which is reversed in its mount so that the front lens is facing towards the film holder, because this improves its optical performance, and an extension is fitted to the back to increase the magnification (bellows draw). This is based on the following principle, that the greater the magnification required on the negative, the closer the lens must be to the subject and the farther away from the lens must the ground glass be (for a theoretical explanation of this technique please refer to the first section of this manual).

Particular care must be taken in macrophotography with the lighting, the depth of field, and the effects of camera shake. The long camera extension results in a very weak image illumination so that a relatively long exposure is needed, further accentuated by the need to stop down as far as possible to secure adequate depth of field. A rigid tripod or stand is therefore essential, and the subject itself must remain absolutely undisturbed during the exposure, the slightest movement being greatly magnified on the negative because of the optical enlargement.

It is a matter of some regret that macrophotography does not number many adherents amongst either amateurs or professionals. It is, however, of great value to the botanist and to the philatelist (stamp-collector), to the collector of coins, and to the mineralogist, to the biologist and to the amateur flower grower, etc. Colour produces the most striking impressions of comparative close-up views of such subjects.

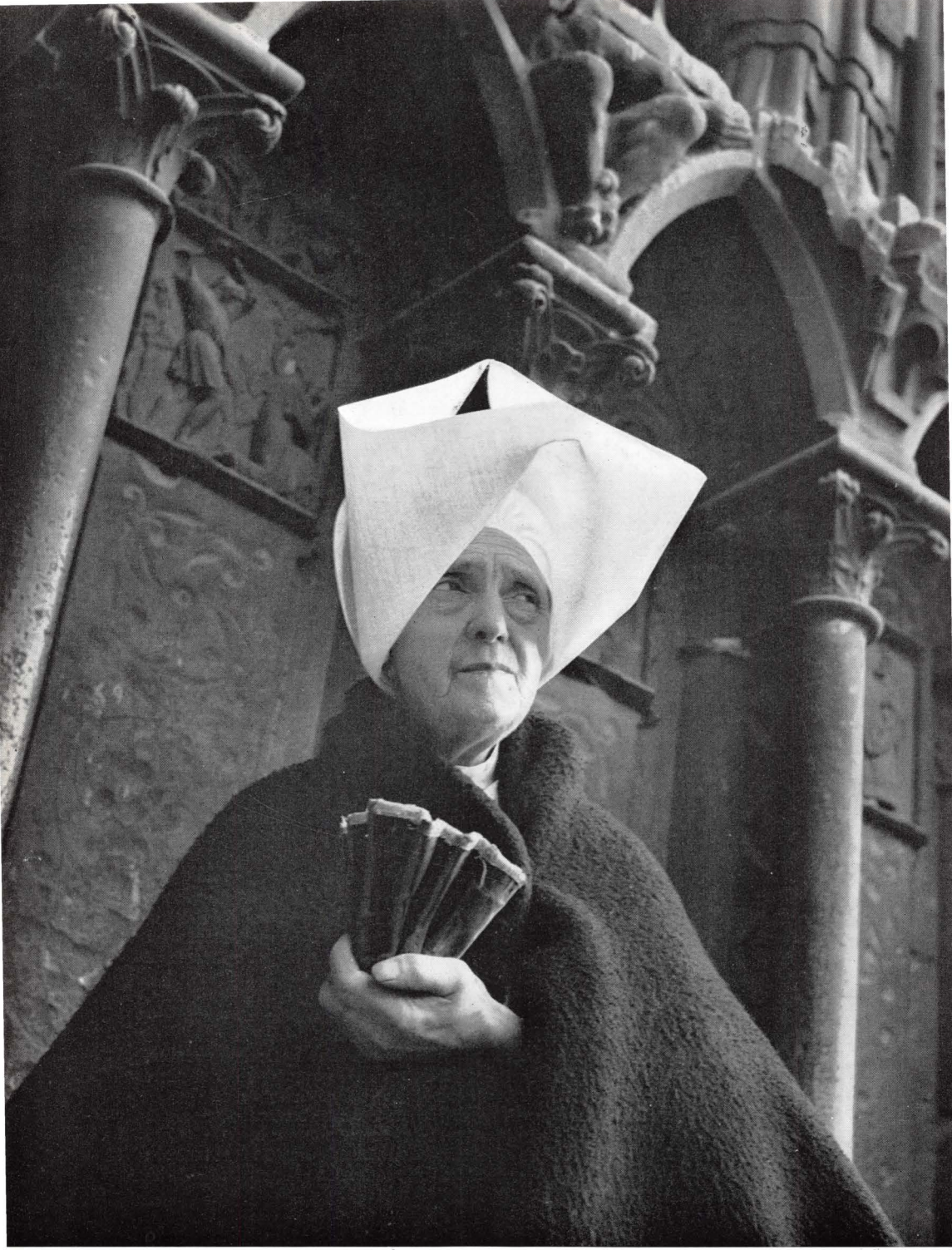


Photo : T. S. Mhajan

FINISHING, PRESENTATION AND MOUNTING

TRIMMING

The unwanted portions of the image need to be trimmed off to leave only the subject proper and with the various elements so disposed that they enhance its importance. This operation plainly needs the application of the principles of composition, a considerable measure of good taste and a discerning eye.

As far as composition is concerned you should turn back and read the chapter dealing generally with taking the picture. Further help can be obtained from experience and from studying the efforts of acknowledged workers. The paramount quality of any photograph should be unity – that is the harmonious grouping of all the different parts of the image around a fixed centre of interest. The balance between light and shade as it affects the 'centre of gravity' of the picture is another quality for lack of which any photograph will lose in artistic value.

You should not hesitate, therefore, to sacrifice deliberately any part of the image which goes contrary to these two tenets and to trim off without mercy any details which, although beautiful in themselves, do not contribute to the effect of the whole.

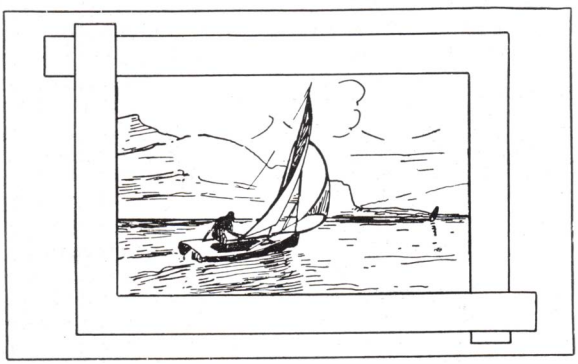
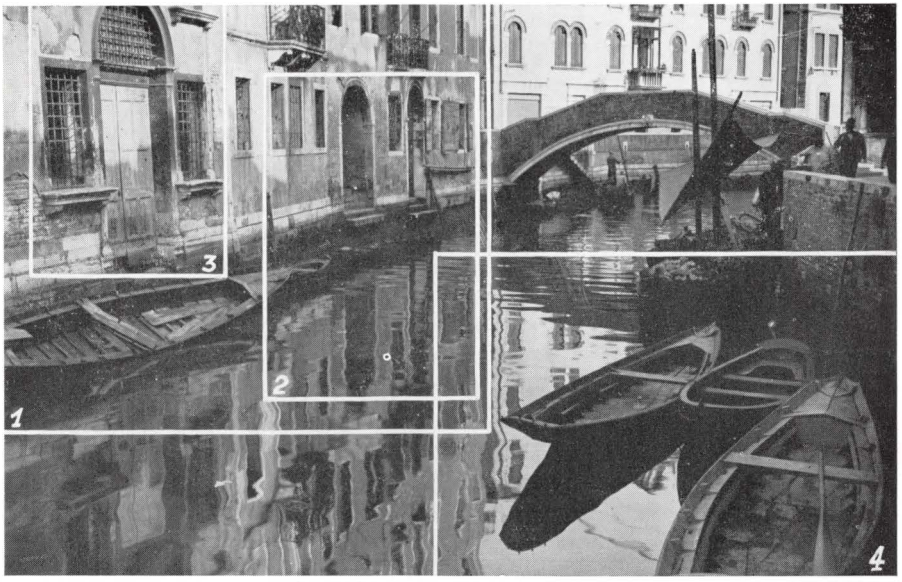


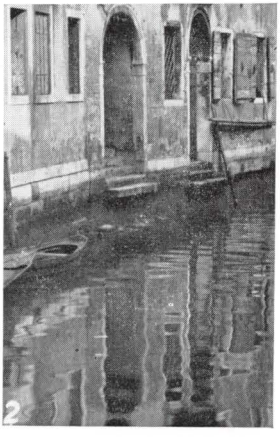
Fig. 79 To assist in selecting the final format two L-shaped pieces of stout card are recommended. These can be manipulated to mask off the areas shown until the desired effect is achieved.

The illustrations (see page 282) show how the subject gains from judicious 'cropping' and how in some instances it is possible to make several interesting studies from a single negative.

Trimming is usually carried out on a print trimmer which can be of the guillotine type, or one of the patented Merritt or table type, operated by foot pedal or by hand. If the guillotine type is used a hand guard or a special


1
2
3
4


1


2


3


4

holding clamp is advisable. They are generally provided with a scaled stop at right angles to the cutter against which the print can be held, a squared base plate and a band (of transparent ruled plastic) alongside the blade with which the paper to be cut can be held and positioned accurately.

If you have no trimmer then the print can be trimmed while still damp using a pair of scissors against the edge of a piece of thick glass, with the portion to be cut off protruding beyond the glass.

Dry prints can also be trimmed on a strong piece of glass, a sheet of zinc, a piece of thick card or strawboard, or any other sufficiently flat material by cutting off the unwanted parts with a very sharp knife, a trimming nib, a scalpel or a razor blade (single sided), using a metal or metal-edged wooden ruler. To prevent the print from slipping while it is being cut it is best to stick it down all round with pressure sensitive tape or with gummed brown paper tape or to cut it on a matted surface.

MOUNTING

Straightening curled prints

Prints tend to curl during drying. To straighten them pass them over a sharp edge (of a table or sideboard) while holding them by diagonally opposite corners. They can also be straightened using a ruler with the print face down on a clean piece of paper. They should be handled carefully so as not to tear them and should be straightened along both diagonals.

If a really flat print is desired for retouching before mounting it is a good idea to stick it down when wet with gummed paper strip all round to a flat board in the way artists treat their watercolour paper to make it dry completely flat.

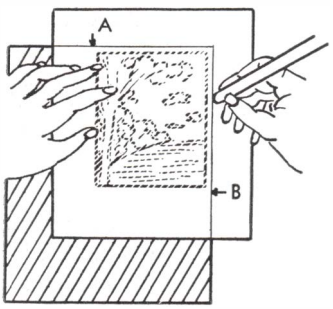


Fig. 80
Making a plate-sunk border

Plate-sunk borders

Pictures which are to be used without any other mount than the paper on which they are printed can be provided with an embossed or indented border round the image.

An extremely simple method, which deserves to be better known, of making embossed frame lines is as follows: Take a piece of strong card and place it so that one corner overlaps the image as far as the frame required and with its edges parallel to the edges of the print. Both the card and the print *must* be *accurately* squared off beforehand. Then mark off the card against the inside overlapping edges of the print. This card we will call the template. Place template on the platen of a contact printer or against a window pane, or somewhere else where it can be examined by transmitted light. Put the print face down on

the template and position the print along the pencilled lines (see fig. 80).

While the sandwich is on the glass make the plate sinking as follows: Take a smooth hard implement of bone, horn, or similar material (such as a toothbrush handle or a paper knife, etc.). Run the edge along the side of the template pressing down the print over its edge. Start at A and finish at B. Turn through 180° and repeat.

Obviously you can make the guide lines on the template for any size of plate sunk surround. It gives a very pleasing effect and will not disappear whatever subsequent operations are carried out on the print such as hot drying, etc.

Plate sinking can be carried out by trimming a piece of thick card to the masking size required, with round corners if these are required and leaving overnight the print, on a smooth soft support such as several layers of blanket or fabric, with the cut-out template positioned carefully over the print and weighted with something *heavy* such as a pile of large books. With stiff print base, such as card, it may be necessary to place a cut-out template slightly larger than the top template under the print to accentuate the pressure. A dry mounting press may also be used.

Choice of mount

Every photograph is improved by the choice of a suitable mount and conversely even the best pictures can be spoiled by an unsuitable presentation.

Traditional embellished, grained, and embossed mounts have been out of fashion now for some time – especially for pictorial prints on matt paper and other special surfaces. The professional and amateur photographer who tries to do artistic work no longer attempts to keep it to a standard format, but tries to increase the impression his work produces by varying the colour of both his mount and the image tone. No one ever uses elaborately marbled or embossed mounts in bright colours. There are available commercially a wide choice of fine modern mounting boards which allow ample variation of size, surface and colour.

Mounting is, however, a matter of taste knowing no fixed rules. A number of general hints can, however, be given. To help decide on the mount prints can be divided into two main groups, the first predominantly light-toned prints, that is, prints with strong highlights and very little deep shadow and the second group predominantly dark-toned prints, with a lot of shadow and only a few highlights. In general, light prints go well on a light-toned mount and dark prints well on dark-toned mounts. This is harmony by similarity. This type of mounting can only be used, however, when it is desired to reduce the effect – for example when a print is slightly too hard. If on the contrary it is desired to accentuate the print effect the opposite choice should be made. Thus a grey print with rather weak tones and contrasts will be strengthened by a dark background whereas strong prints with dark shadows will show up well on light mounts. It can be said in a general way that a dark mount will emphasize the effect of the deep shadows.

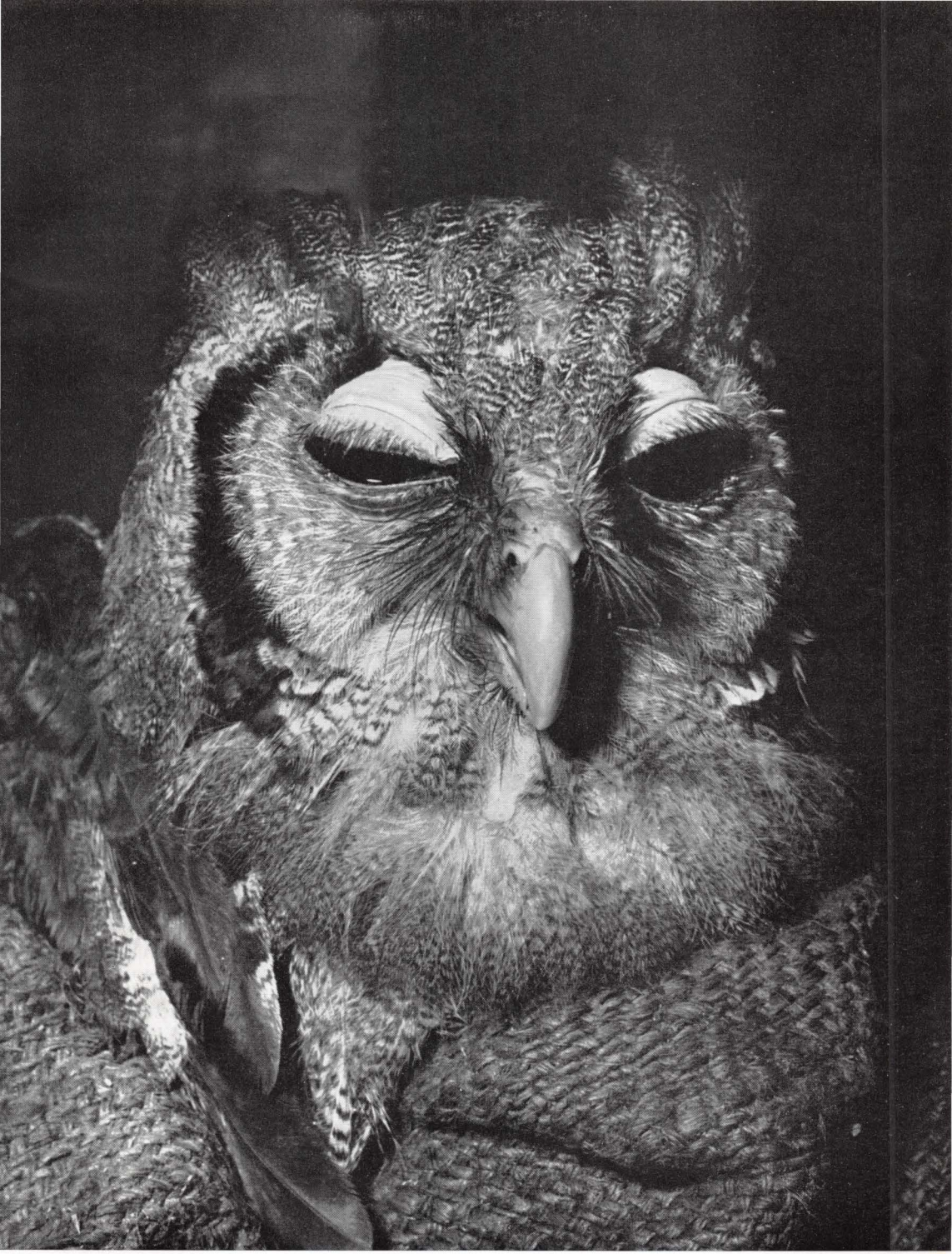
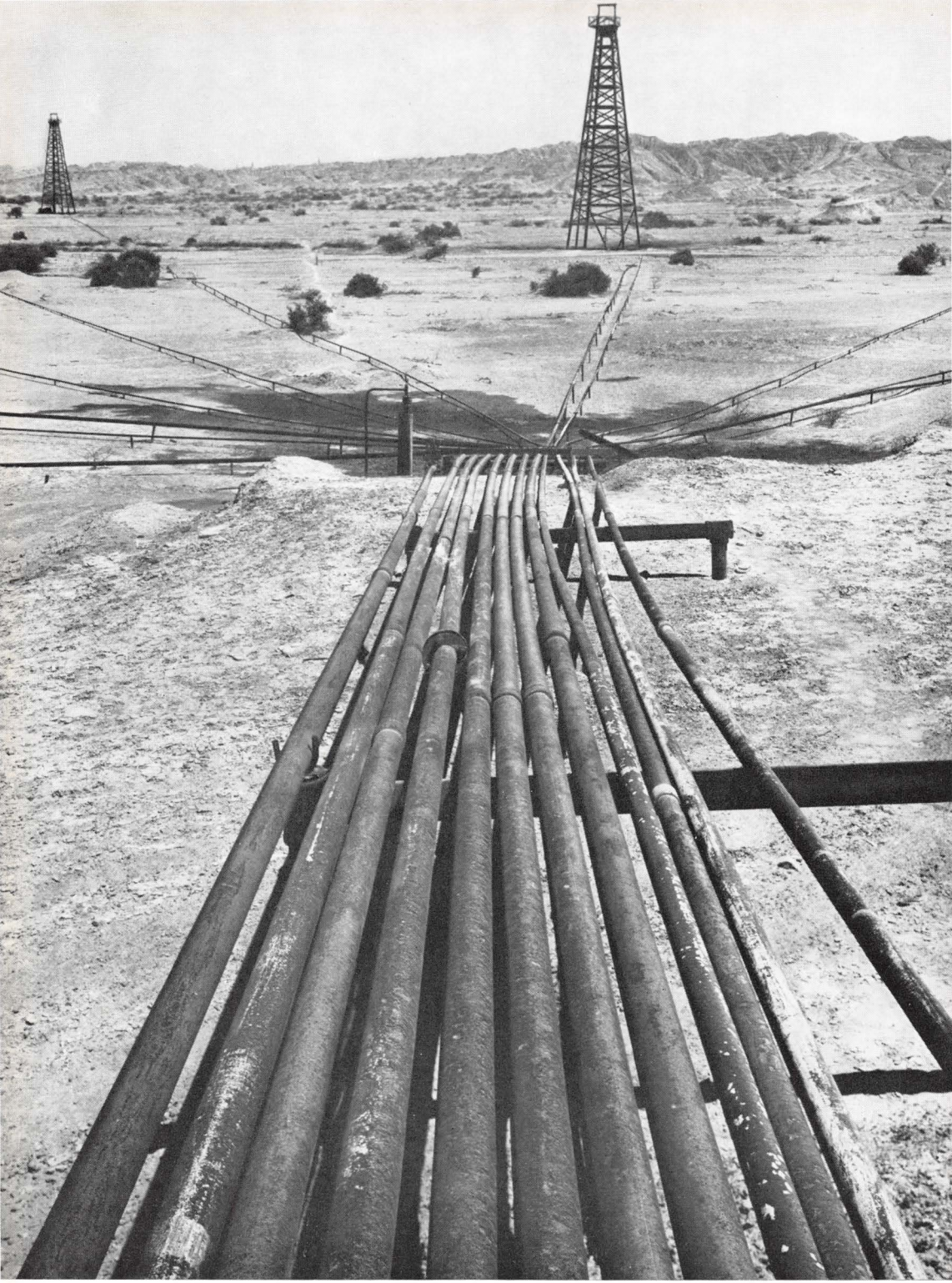


Photo: David Seymour



Position of print on mount

The diagrams of fig. 81 show the normal conventional placings. You can sometimes obtain an improved effect by moving the image towards one of the corners, e.g. to accentuate a diagonal composition. A slanted mount can also be used in certain cases.

The main thing is not to overdo things with an extravagant or exaggerated positioning. Any way of mounting is satisfactory provided it springs from the picture itself. On the other hand any way of mounting that is inspired by ideas unconnected with the picture should be rejected.

To find the best position proceed by trial and error. When the best position has been found mark the corners with a sharp hard pencil.

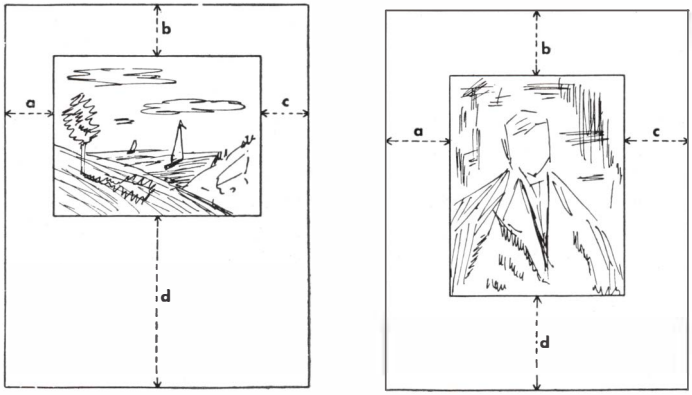


Fig. 81 Traditional placings: d is longer than a, b and c; a=b=c

A modern device much in favour is to 'bleed' the print off one or more edges, i.e. have no mount margin showing there at all. This is most effective with 'texture' pictures which completely occupy the mount all over with no margins. Like any other device it should be employed with discretion and taste.

MOUNTING

Carry out the mounting in a well-ventilated warm dry place. Rapid drying of mounted prints helps to keep them in good condition.

Mounting with paste

Place the print, still wet, face down on a sheet of glass, squeeze off any excess water with a blade or roller squeegee or with blotting paper or a swab of cotton wool. Then coat the back with fresh starch paste while still wet and stick the print to the mount.

← *Photo: Standard Oil Co.*

The print on the mount should be dried thoroughly in warm dry air. In summertime they can be air dried. In winter or wet weather keep the prints in a warm place but do not put them too close to the fire.

If the mount tends to curl inwards paste a piece of thick paper wet on the back to balance the tension caused by the print.

When only the top edge of the print is to be stuck to the mount put a thin line of thick paste along this edge (a little way from the edge). To fasten down by the corners alone use freshly prepared gum arabic, transparent gummed corners or strips gummed on both sides.

Good paste contains no acid, nor any hygroscopic material. Acid in paste (or mounting card) will affect the image tone in time, especially if the print has not been thoroughly fixed or washed: hygroscopic materials by absorbing water cause impurities in the air to attack the image and cause all kinds of faults, discolouration, areas of uneven density, etc., as a result.

Gevaert 'Gevacol' is particularly recommended for mounting complete prints. It is prepared from pure constituents under factory controlled conditions so that it is guaranteed to satisfy the user. There are a number of proprietary pure dextrine pastes, containing preservative, sold by reputable dealers especially for mounting photographs, but only a thoroughly reliable paste should be used.

Prints to be mounted by the corners only should be thoroughly dried before sticking; those which are to be stuck over their whole area should be damp. A number of prints can be placed one on top of the other face down on a well-cleaned sheet of glass, the largest underneath the smallest on top. Spread the paste on the back in a thin even layer using a large brush. When covered, lift up the top print with a knife and place it carefully in position on its mount while holding it by two opposite corners. Make sure the print is square with the edges by carefully marking the corner positions beforehand on the mount. Cover the print with a sheet of filter paper or photo-blotting paper and press the print down firmly with the palm of the hand working from the centre outwards to the edges or use a rubber-covered roller squeegee. Any blisters or pockets can be removed by raising and lowering the print slowly. If dry prints are to be mounted all over with a liquid paste then let them soak for several minutes in water and then mount them as described above. This procedure may sometimes cause trouble (splitting and cracking) and should be avoided if possible, particularly if thin lightweight papers are being mounted, as these do not stand a second wetting and drying well.

Dry mounting

Dry mounting with tissue is the simplest and easiest method. Professional photographers mount their prints with shellac tissue in the following manner: Fasten to the back of the print (untrimmed) a sheet of dry mounting tissue (use double-coated tissue for heavyweight or card based prints) using for the purpose a small heated 'tacking' iron (similar to a soldering iron) or the tip of a domestic iron. Then trim print and tissue together so that they are exactly the same size. Place



Vienna, capital of the Waltz – Photo : David Seymour



the print and tissue on the mount, position carefully and then tack temporarily in place by lifting the corners and fastening the tissue to the mount at the corners with the small tacking iron. The sandwich is now ready for the press. Put it all between two sheets of absolutely dry cardboard or special zinc plates, or a polished glazing plate for glossy prints and place it in a heated press. Usually the top plate of the press is heated by gas or electricity and maintained thermostatically at a pre-set temperature of about 150°–180°F. (80°C.). The heat melts the shellac on the mounting tissue and sticks the print securely to the mounting board.

A domestic flat iron can be used instead of a heated press if necessary. A thermostatically controlled electric iron is quite suitable and should be used on a firm dry base composed of a flat piece of wood covered with a few sheets of thoroughly dry newspaper. Get the temperature of the iron correct, testing it to make sure it does not scorch a sheet of plain dry paper (try the 'cotton' or 'rayon' setting first). Use a firm even pressure and keep the iron moving slowly working in an outwards direction.

The print will stick to the covering plate, card or paper if it is not thoroughly dry before it is mounted. It will also shrink and show a small margin of tissue round the edge. Carefully pre-dry the card, which will hold a lot of water, so that it is flat and does not cockle in the press. Before you mount a valuable print test out your apparatus on something less valuable to make sure you have everything in correct order.

See that the print, the covering cards and metal plates are completely clean. The pressures developed in modern presses are high and the slightest piece of dust, grit or foreign matter will cause the print surface to be embossed or pitted with a mark which is most noticeable with a glossy print.

After mounting by both dry and wet methods the mounts have a tendency to curl. To avoid this they can be stuck with a gelatine adhesive. Another method of counteracting curl is to stick on the back of the mount a sheet of paper of about the same weight and size as the print in a position corresponding to it. This equalizes the tensions on the mount and keeps it flat.

RETOUCHING OF POSITIVES

Retouching on positives, especially paper prints, is mainly a question of spotting, or of retouching with an airbrush. It should always be exactly the same colour and shade of the image itself and must be both invisible and durable.

Spotting

Small white spots, caused by dust on the negative, and white lines due to scratches or abrasion can be covered up on the print by using a fine brush and watercolour mixed with a gum arabic solution. The colour is mixed up on a small porcelain palette. The gum arabic gives the retouching a gloss and also

← *René van Grootloon*

makes it more permanent. Use very little gum for matt and semi-matt papers. For glossy papers a little egg-white (albumen) can be added to produce the desired shine. Diluted indian ink may also be used quite satisfactorily. When the correct shade of colour has been mixed (test it on the margin of the print, or a reject) the smallest spots are touched gently with the point of a fine brush which has been barely moistened with the colour, taking extreme care not to go over the edge of the white area. Work with a vertical stabbing motion, applying small spots of colour one by one until the area is covered in a 'pointolist' style. It is not necessary to cover all the white provided the dots of colour are close together and give the desired appearance. Avoid moistening the gelatine layer at all costs.

Very small spots can be 'spotted out' using a fine pencil point, B or HB. This is simpler, but less permanent and may be subsequently smudged although some workers apply the powdered graphite and rub it down with finger tip, a wooden stick (an 'orange' stick), or an artist's paper stump, such as is used with stumping crayon powder.

Knifing

Dark lines and spots can be removed by knifing, although in general it is better to convert them to white spots and lines by retouching the negative beforehand. Keep the scalpel sharp and scrape the emulsion off in thin parings until the desired effect is obtained; regloss on shiny prints with gum arabic or mucilage solution.

Bleaching

Some exhibition workers, especially those who work from small negatives, resort to bleaching on the print with ferricyanide, or Farmers' reducer. A small crystal of ferricyanide placed on a black spot, previously moistened, will bleach it away. Use a magnifier to observe progress, and refix and wash thoroughly after treatment. Larger areas may be swabbed with a dilute solution, preferably mixed with hypo, and the effect stopped before the desired reduction has been quite accomplished. Small catchlights or highlights to delineate shape may be added with a fine brush. Each worker will develop his own methods, and many are described in the literature of pictorial work. In general some restraint is desirable, although by judicious overprinting and subsequent reduction changes of emphasis and contrast can be produced which have definite pictorial merit.

In cases where it is desired to bleach out whole areas of background and airbrushing is not acceptable, the iodine-thiocarbamide reducer may be used, and suitable solutions are on sale commercially, in quantities suitable for use. The action of the reducer, in this the iodine, is restrained by using a modifier, and some skill is required to control the rate and reaction of bleaching. Since there is no accompanying yellow staining this method is frequently preferred. Thorough washing is essential after all chemical treatments of prints if they are to be permanent.

Dancers in Bali – Photo: Henri Cartier Bresson →





Paper negative work

An alternative method for pictorial work, where the negatives are small, and particularly when the originals are on 35 mm. colour reversal material, is to use a full-sized paper negative as an intermediate on which extensive retouching can be done. In working from a negative too small to retouch, a positive can first be made, either on a lantern slide or on paper, and this can then be retouched to remove all unwanted light areas by toning them down. This is then subsequently printed on to a full-sized piece of *white based* paper as a negative which can then be pencil retouched on the back to produce a wide variety of effects. If a smooth result is required, and the retouching is carefully executed, an opal paper such as K34 or the same surface on a lightweight base can be used. If broad effects with much drawn work is required then a rough paper on a heavier base will probably be preferred, such as K44. The apparatus required is simple and the materials relatively cheap, only patience and taste are required. Be careful to judge your paper negative, and intermediate positive by transmitted light. When viewed by reflected light it should appear far heavier than an ordinary print or it will not give good prints by contact.

The methods used for retouching both positives and paper negatives may be any of those given above for more straightforward processes, but remember to judge the retouching by the *same type of light* as will be used to print from the paper negative.

Darkening print shadows

Some workers prefer to darken down the shadows, or selected areas, of the print, not by reducing or knifing the negative but by applying pigment of some sort to the print itself. Apart from an increased depth caused by varnishing or waxing the print they may use an oil paint or dark polish or stain applied with a swab to the area concerned. A favourite with some workers is a wax boot polish in the appropriate shade of black or brown, frequently diluted on the pad with a little methylated spirits. Such methods are more suited to the production of a single exhibition print, where the precise result is observed as it is built up. Negative retouching for subsequent multiple printing will be more favoured by the professional.

Airbrush work

Retouching with the airbrush is predominantly a professional practice, commercial artists in the process and advertising studios specializing in this work. A skilful retoucher can even use the airbrush for negative retouching, to hold back by a light application of red or neutral dye or colour those areas which could otherwise print too dark. The capabilities of the airbrush are limited only by the skill, patience, and imagination of the user.

In this method colour is applied in a fine spray using a small accurately controlled nozzle which is operated by finger pressure, being held in the hand like a brush or pencil. The artist

← *Photo: Ergy Landau*

generally uses a special grade of fine watercolour, prepared so that it will not clog the fine nozzle, and the air pressure is supplied from a reservoir fitted with a gauge, and charged by a footpump or from a pump driven by an electric motor, the pressure being regulated by a valve. By varying the nozzle adjustment and the distance of airbrush from the work a great variation in width and density of stroke may be obtained.

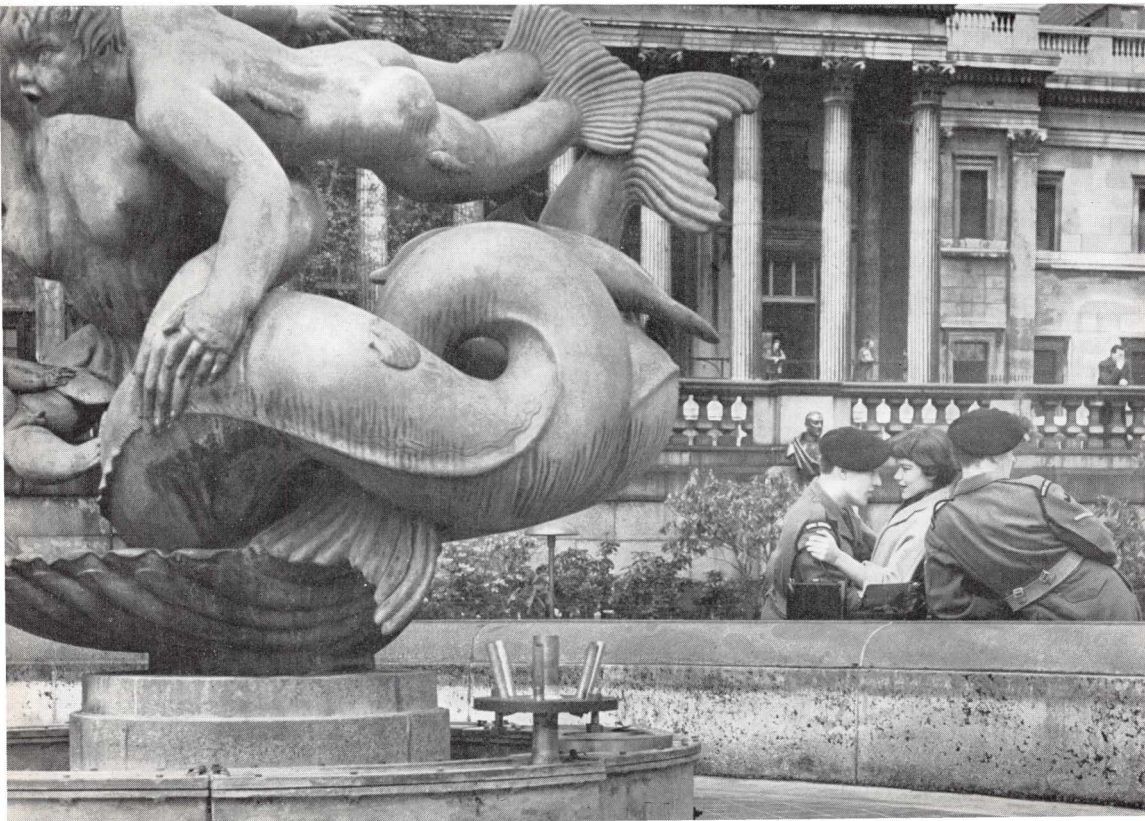
Enlargements which are too light or need parts added are particularly easily retouched by the use of an airbrush. A sky that is too light can be greyed over, and cloud effects can be added without these added effects being detectable on the print. Wedding photographs, where the bride's dress is too white and lacking in detail, can be much 'improved' in this way. Needless to say, a competent attention to exposure and development, plus some judicious 'shading' during printing, would probably produce a more pleasing result.

The airbrush has found its particular application, as has 'blocking out', on prints which have subsequently to be used for book, catalogue, magazine and newspaper reproduction. High speed gravure work for instance is produced almost exclusively from print paste-ups without subsequent retouching, which must therefore be correct on the prints used. Its speed and certainty in skilled hands is a particular advantage.

Where fine work has to be done, or the work is to be confined to specific areas, it is normal to cut out a mask of transparent paper to protect the rest of the work. If the paper is slightly sticky so that it adheres gently to the print when pressed in contact, this is of great convenience. Masking papers of this type ('Transvarn' is one) are available from most process supply houses together with a large range overprinted with screens and patterns which artists can use to modify the appearances of prints as they desire.

The airbrush projects a fine jet of colour. The colour used must be of good quality, and must be free of lumps and grit. After diluting the colour with water it can be filtered if desired. Always clean out the brush with water immediately after use and do not allow any colour to dry on the brush to cake and obstruct it.

Lovers in London – Photo: John Erith



The colour dries practically instantaneously when using an airbrush. Nevertheless, do not apply too much colour to any part of the print at one time. Build it up slowly for preference by several applications allowing some few seconds to elapse for each coating to dry thoroughly. In this way all risk of running or drops will be avoided. Glossy papers cannot be retouched by airbrush without the watercolour showing afterwards unless a gum spray or varnish is afterwards applied. The velvet surfaces of 'Gevatone' K28 and K29 and 'Artona' K31 are particularly suitable, as their velvet surface readily takes the colour up and fixes it immediately.

Photo : Roger Schall



Waxing

A simple way of hiding any type of print retouching, especially on matt, rough or lustre surfaces, and one which many exhibition workers advocate because they say it increases the tonal range by deepening the blacks (i.e. making them reflect less diffuse light), is to cover the whole print with either a layer of a spirit varnish, or better still with a layer of pure wax polish, either a cake furniture polish, or a carnuba wax polish as used for car polishing, or better still one of the liquid quick drying polishes incorporating a petroleum solvent and silicones. These are simply applied by rubbing gently with a soft fluffless pad, allowed to evaporate and then gently polished with a dry cloth until the degree of shine required is obtained. The solid wax is less easy to apply, and should not be used on a wet cloth whatever the directions on the tin say, but there is less risk of smudging any retouching if this has been extensive.

FRAMING

A fine picture, especially if enlarged, deserves to be framed. It will always be improved by framing and we can in addition use it to decorate our walls. Nothing is more slapdash than a picture put up 'temporarily' with drawing pins but left for months on end at the mercy of everyday dust and dirt, temperature changes, and the effects of sunlight which rob it day by day of its freshness.

As the frame is intended solely to make the photograph stand out from its background quite a simple style should be chosen, which harmonizes well with the picture and its mount and gives a clear contrast with the surroundings against which it is to be placed. Materials suitable for doing your own framing are readily available, all that is necessary is to obtain a piece of glass of the correct size. Avoid greenish window glass and see that it is flat and free of flaws. Check on purchasing that it is cut accurately to size.

Small and medium sizes can be framed using gummed paper strip ('passe-partout', etc.) which is sold in a large variety of colours and surfaces. Larger prints or ones which are particularly prized can be framed in mouldings, which can be bought by the foot from handicraft shops and made up into frames of the right size. This occupation is a pleasant one for winter evenings but requires some practice and ability at woodwork and a few simple tools including particularly an accurate *metal* mitre block to cut the corners and a corner clamp which will hold a glued corner accurately at right angles until it is properly set. Without the proper tools considerably more skill is required to make satisfactory frames. An alternative source is to attend an auction sale or two and buy up some old pictures for their frames. These can be repainted and the more elaborate ones which are often moulded in plaster lend themselves to alterations with plaster of paris and an imaginative hand. Study the framings used by painters and galleries, this will give you ideas for your own work.

Obviously for standard sized prints, especially the small sizes such as $\frac{1}{4}$-plate, 5×4, 5×7, 10×8, etc., you can use one of the wide choice mass produced frames on sale.

Photo: R. Reusens →




TOUR D'ARGENT

LANTERN SLIDES*

The notable increase in the use of reversible colour film during recent years has resulted in the average man in the street who takes photographs becoming increasingly interested in lantern slide projection, especially of 35 mm. transparencies. Serious amateurs and some professionals have, however, always been keenly interested in diapositives and some of the older pictorial workers have shown a mastery of this medium with the larger sized lantern slide which will probably never be surpassed. In addition the larger transparency in black and white and colour has become increasingly popular for window and exhibition stand display and has an important place in direct advertising. It is a fact that a diapositive (*literally* 'through positive', i.e. a positive that is viewed by transmitted light) can show better than a print on paper can, all the tone and nuances of the image. The highlights are well separated and modulated, while at the same time the shadows are clearly shown and full of detail. These qualities of the lantern slide are displayed to full advantage in pictures with a very long range of contrasts of light and shade.

The reason lies in the much greater 'brightness-range' of the lantern slide. This range, which for ordinary photographic papers does not usually exceed 1 : 40 or at most 1 : 50, can be as high as 1 : 1,000 for black and white transparencies while the range for reversal colour film is very little less than that for the black-and-white material.

Brightness differences of 1 : 1,000 are frequently found in nature, hence lantern slides can give a much more faithful reproduction of natural contrasts than can prints on paper.

A lantern slide, whether it is black-and-white or colour, can be seen to best advantage when projected on to a suitable screen under good conditions. Projectors are on sale at all big dealers. Table viewers for the 2×2 size, which give an enlarged image on a built-in translucent screen, are also on sale. The projector or viewer is placed on the table and the whole family can settle down comfortably in front of it to look at their slides. There are also available a large variety of hand viewers, some with built-in battery or low voltage illumination. The slide is then examined against a translucent screen by looking through a magnifying lens provided. The effect is very realistic.

The projection of slides is not only of interest to the amateur. Everyone has heard of the 'illustrated lantern lecture'. Without the lantern the lecture would

* By J. Welffens.

← *Photo: Daniel Masclet*

lose a good deal of its audience. Similarly, in teaching, commerce, industry, laboratories and scientific institutions lantern slide (or film strip) projection has acquired a new importance. Doesn't an old Chinese proverb say that a single picture means more than a thousand words?

HOW ARE LANTERN SLIDES MADE?

This question embraces among others the following points:

1. What size should we use for our lantern slides?
2. Shall we make them in black-and-white or colour?
3. Shall we use reversal film or use a 'negative-positive' process?

These questions are dealt with one by one below.



Sizes

Transparencies can be made in practically any size. If they are to be projected, however, they must obviously be made to fit into the projector which is to be used. Slides are usually mounted between two thin sheets of glass. The overall size is either 2 in. × 2 in. (5 cm. × 5 cm.) for miniature slides, or $2\frac{3}{4}$ in. × $2\frac{3}{4}$ in. (7 cm. × 7 cm.) for $2\frac{1}{4}$ in. square (120) transparencies. $2\frac{1}{4}$ × $3\frac{1}{4}$ in. transparencies are mounted between glasses $3\frac{1}{4}$ in. × $3\frac{1}{4}$ in. in size (in Britain) and 4 in. × $3\frac{1}{4}$ in. (8·5 cm. × 10 cm.) in America and on the Continent (for standard sizes and arrangement of images see B.S. 1917: 1952 and American Standard A.S.A. Z38.7.13–1944 obtainable through any technical bookshop.) For the larger sizes glass plates coated with a slow positive emulsion and sold as lantern slide plates are available in a choice of speeds, contrasts and image tones, in smaller but similar variety to photographic papers.

The miniature 35 mm. size is the most popular. This is not surprising for both film and projectors for the 35 mm. size are cheaper, more economical and easier to obtain, than films and projectors for larger sizes, and the quality of the 35 mm. pictures (24 mm. × 36 mm.) is excellent. (Recollect for a moment that the size of the individual picture frames shown on large cinemas is only 16 mm. × 22 mm. even for 'wide-screen' presentation.)

The $2\frac{1}{4}$ in. square size has a considerable following, especially in America and Germany among colour workers. The ground glass screen of the twin lens reflex is a great help in composing colour pictures which have to be used exactly as taken and this is one reason why this format is so popular.

The larger sizes are still used to a great extent, especially for professional purposes (publicity projection, etc.) and in older institutions equipped for the larger sizes, but in addition by serious amateurs who maintain, not without reason, that the larger the size of the slide the better the projected result, moreover for particularly difficult work the size of the larger image allows for manipulation, shading, critical focusing and individual processing and retouching which is impossible on the smaller sizes.

Black-and-white or colours?

This is an academic question to which we can give no straightforward reply. Will colour film completely supplant black-and-white? Who can say? But it does not seem very probable.

The growing popularity of colour films for making transparencies should not surprise us. People love colour and colour photography helps them to see and notice the colours of a marvellous world that previously they had hardly realized existed. On the other hand interest in black-and-white slides remains as firm as ever. And with good reason. Black-and white work has to its credit such a wealth of performance, both technically and artistically, that there is no need to defend its prestige against anything. The amateur is free to choose. For the teacher, the commercial traveller and the laboratory worker colour may be preferred to black-and-white for certain types of work – for reasons which are concerned with the job in hand, professional or scientific.

← *Størstrøm Bridge in Denmark – Photo: Carl Rindelaub*

Reversal, or negative-positive

The negative-positive process is familiar to all. A film is exposed and after development we have a negative from which a positive print is made on photographic paper by contact printing or by enlarging. But if the same negative is printed or enlarged on to a piece of transparent film or on to a plate then, instead of a positive paper print, we get a positive transparency or diapositive.

There is, however, a rather simpler method for making positives by the so-called 'reversal' method. By 'reversing' the film we mean the conversion after development of the original negative image itself into the corresponding positive form on the original piece of film. We convert it by first getting rid of the black



silver which is the negative image – in the emulsion layer by immersing the film in a special bleaching or silver removing bath. The remaining unblackened emulsion is then exposed and developed. The result is a positive image, i.e. a diapositive.

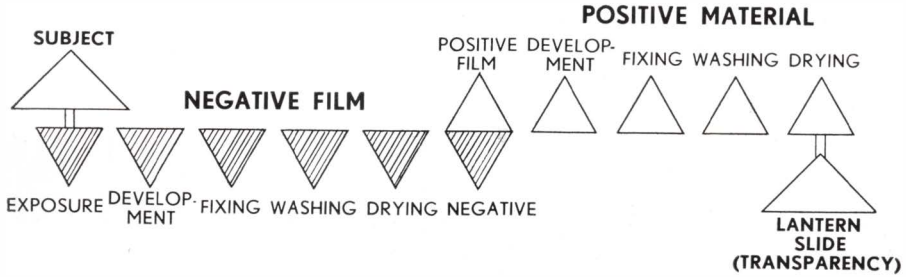


Fig. 82 Diagram showing negative-positive process schematically.

No matter what film is used it can in principle be reversed, but it may be readily appreciated that in the long run special 'Reversal' films manufactured for this purpose will give the best (and most consistent) results. Reversal processing, which is a little more critical and complicated than straightforward negative and positive processing, is usually carried out by the film manufacturer or in specially equipped processing laboratories.

In recent years formulae and procedures have been published for reversal processing of most popular negative emulsions as well as positive film and plates. The chief difficulties are that the exposure latitude is reduced somewhat and that if clear whites are required, and this is desirable, although not always essential, the chemical processes need careful attention and judgment. Another serious difficulty for professional and institutional work is that the negative no longer exists as an intermediate for further use, and the positive because of its very usefulness can easily be damaged or destroyed.

How should we choose in practice between these two methods?

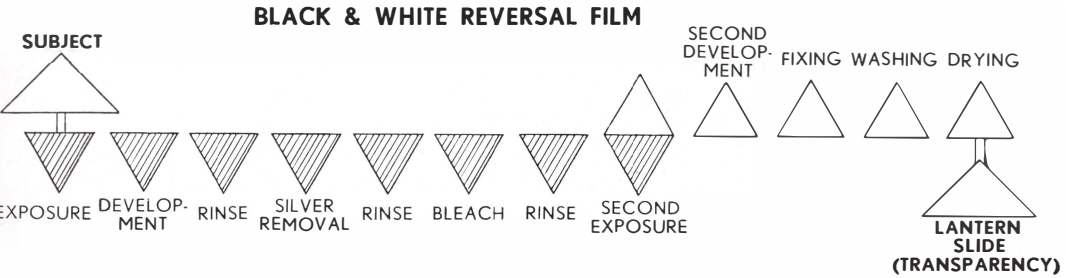


Fig. 83 Diagram showing 'reversal' process schematically.

← *Photo: Max Koot*

For normal work the reversal system will give clearer brighter results than the negative-positive. This is because the nature of the system itself is such that printing or enlarging is unnecessary, operations which always result in some loss of sharpness and gradation in the image, however carefully they are carried out. Dust spots also show as black spots instead of white and are much less noticeable. In addition all you have to do is to take your pictures and then send off the film to the factory or the reversal laboratory and a few days later you get your transparencies back all ready for use.



'Gevacolor Reversal' colour films incidentally are reversal films which must be processed in special laboratories equipped for the work.

For black-and-white work Gevaert make only one reversal type film: 'Dia-Direct 26 Pan Reversal' in 35 mm. size which is returned to a specialized laboratory for processing, the cost of which is included in the selling price of the film.

If you want, for any particular reason, to carry out all the work yourself you can use the negative-positive process for black-and-white work. Select your best negatives and print them – reducing or enlarging if you wish – on to 'Duplo Copy' film 35 mm. miniature size or on to lantern plates ('Diapositive' in two grades of contrast – 'Contrast' and 'Normal' – available in a number of different sizes). In this way you can make lantern slides to suit whatever viewing (or projecting) system you want to use. You can control the contrast of your lantern slides, and in fact you have four variable factors with which you can vary the contrast (and depth) of the image as you please: the exposure and development of the negative and the exposure and development of the lantern plate.

Finally the negative-positive process is the only process which allows you to make as many slides from one negative as you wish, although, of course, you can take more than one reversal positive, or make a copy negative from such a positive if you wish to duplicate it.

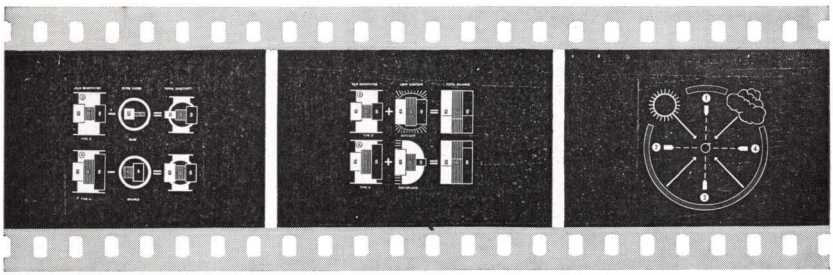


Fig. 84 Line diagrams copied on 'Duplofilm'.

Lantern slides or line diagrams and tables

These days a scientific or technical lecture can be strikingly illustrated by a series of reproductions of text or drawings taken from the relevant professional periodicals or books. In most cases, moreover, these need not be projected as positives since negatives are quite sufficient and may even be superior for projection purposes from several points of view.

Experience shows in fact that white lettering or white lines on an opaque black background shows up as clearly – if not better – on projection than the same words in black on a white background and in addition cause less eye fatigue and strain (see fig. 84).

For copying line diagrams and text Gevaert make special 'microfilms' called 'Duplofilms'. These films have high resolving power and give images with

← *Photo: Willy Ronis*

dense black background and very clear whites, so ensuring readability and perfect clarity on projection.

One of the great advantages of 'negative' slides is the ease with which one or more details may be picked out by staining the gelatine locally with transparent negative dye. Since the background is a dense black no great accuracy is required and it is possible using a magnifier to colour with a brush small details on even 2 × 2 slides by this method.

Gevaert positive materials for lantern slides

Type of film or plate	*Name*	*Purpose*
Reversal colour film for daylight	'Gevacolor Reversal R5'	Colour transparencies in daylight or with blue flash bulbs or electronic flash on the original camera film
Reversal black and white film	'Dia-Direct 26 Pan Reversal'	Black and white transparencies on the original camera film
Lantern slide plates	'Diapositive Normal'	Black and white slides from all sizes of negative by contact, enlargement or reduction
	'Diapositive Contrast'	'Normal' for printing normal negatives, 'Contrast' for soft negatives (or for line subjects)
Negative microfilms	'Duplo Ortho' 'Duplo Pan' 'Duplo Pan-Rapid'	Copying all types of documents, book extracts, periodicals and line diagrams, etc.
Positive microfilms	'Duplo Copy'	Positive prints from microfilm negatives (of line subjects) (or by reduction or enlargement from other negatives if required)

DARKROOM WORK

★ Darkroom illumination

Gevaert films and plates must be handled and processed in the darkroom in the correct 'safe' illumination.

★ Recommended safelight filters for use in the darkroom

Gevaert positive emulsion	*Safelight colour*	*'Gevinac' Filter*
'Diapositive Normal' Plate	Greenish-yellow	X 572
'Diapositive Contrast' Plate	Orange	L 552
'Duplo Ortho' Film	Dark red	L 652
'Duplo Pan' and 'Duplo Pan Rapid' Film	Dark green	X 535
'Duplo Copy' Film	Light red	L 611

Contact printing on lantern plates or films

An ordinary printer (or contact printing frame) is quite satisfactory for making positive copies from negatives on positive films or lantern plates. You proceed in exactly the same way as you do for making prints on paper.

To make contact diapositives from 35 mm. negatives, use one of the commercially available printing boxes made specially for the purpose such as the Leitz 'Eldia' shown in fig. 85. It can also be used satisfactorily under an enlarger as a holder for the positive film. This apparatus is intended for making a number of transparencies on a roll or strip of positive film for development in a spiral tank but beginners are advised to use short lengths of positive film, not wound on to the spools, and removed after exposure and developed individually. The great enemy in all this work is *DUST*. Larger negatives can be printed on a normal contact printer or in a contact printing frame.

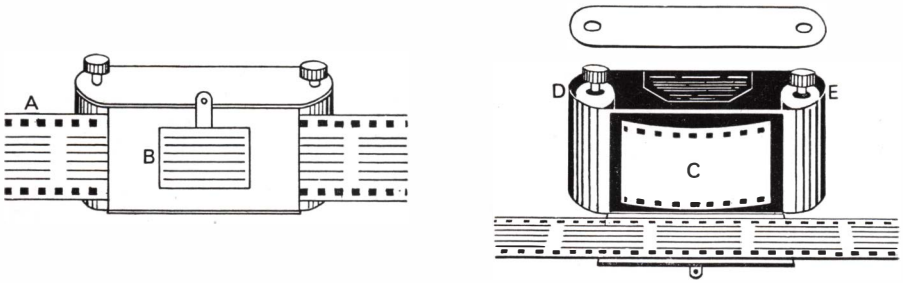


Fig. 85 'Eldia' Contact Printer
A = Miniature negative, B = Pressure plate, C = Positive film,
D = Take up spool, E = Supply spool.

Expose to a medium wattage lamp placed at a fixed distance from the printing frame. Better still place the frame on the baseboard of an enlarger and use the light from it with no negative in the holder to expose the positive. You then have at your disposal two means of varying the light intensity: the distance of the enlarger lens from the printing frame and the diaphragm of the enlarger lens.

A few test exposures will soon determine the correct exposure required. If you are using lantern plates you can cut one into quarters or into five strips so as not to waste a complete plate for each test. You will need a good diamond and a little practice to do this well.

Enlarging or reducing negatives

Some time or other you will want slides which are larger or smaller than the actual negative. To enlarge you can naturally use exactly the same methods as for making prints by enlargement. You enlarge the negative on to a lantern plate instead of photographic paper and that is all there is to it. You have to take into account the thickness of the glass plate of course; a good idea is to use

a waste plate emulsion up towards the lens to focus on. On small plates you may find this operation difficult to do critically, and the help of a focusing magnifier will be useful. Remember not to stop down too far, or too much between focusing and exposure. An unsharp negative rarely makes a good slide, and an unsharp slide is shown up unmercifully when it is projected to a large size on the screen.

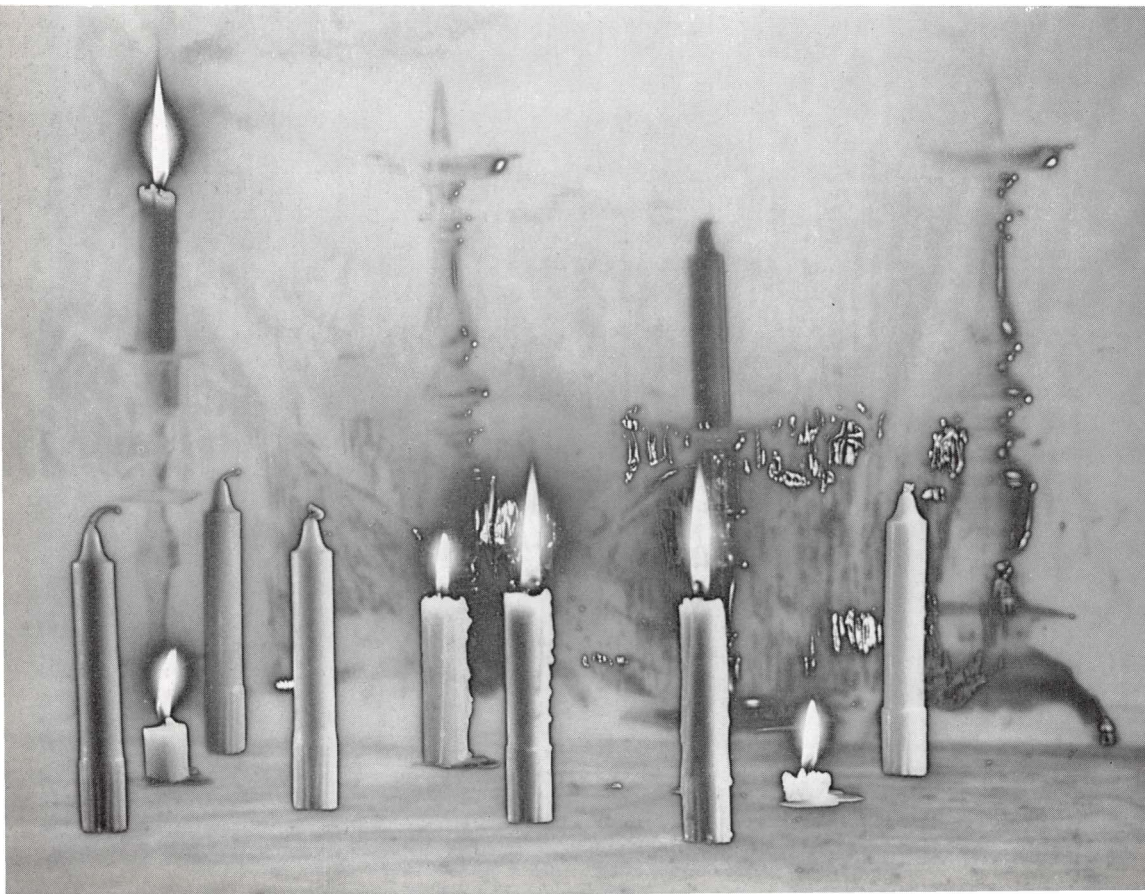
If you want to make a reduced size positive from a negative you can equally well use an enlarger or a suitable camera.

Only enlargers with a long bellows draw can be used for this purpose. Because the positive image is smaller than that on the negative, the negative-lens distance has to be more than twice the focal length of the enlarger lens. It may be advisable in some cases to turn the enlarger lens back to front.

With such a long bellows draw, however, there is one great disadvantage – it becomes very difficult to focus accurately. If you have an enlarger with a fine control on the enlarger head (negative stage) then focus finally by moving this

This photograph was created by an arrangement of cylinders to produce a harmony of light and shadow. The hazy effect of the background was obtained by placing a sheet of cellophane behind the sharp foreground. The negative was partially reversed by the Sabattier effect. The enlargement was printed in the usual way on bromide paper. By this means the photographer attained the desired atmosphere.

Photographer: Mario Finazzi



and *not* the lens, which needs to be set to give the correct reduction only. This is analogous to the use of back focusing with a copying camera. For this type of work most photographers prefer as a consequence to use a double extension copy camera or a camera fitted with an extension tube behind the lens with which the negative is simply copied on to the positive material. The negative is placed on an illuminating box, a vertical column holds the camera above it. Focusing is done on a ground glass screen with a suitable magnifier. It is usually necessary to equip the camera with a holder to take the size of sensitive material used for the positive. If a 2 × 2 in. slide is being made, however, any suitable 35 mm. camera will do.

Development

Gevaert Positive materials should, for preference, be developed in a commercial MQ developer. 'Metinol U' Developer, which is available commercially, is particularly recommended. This developer is sold in tins as a white powder which has only to be dissolved in water to give a developer ready for use.

If you wish, however, to make up your own solution, the recommended formula is G.251 (see Part V).

Photo: Stig. T. Karlsson



The time of development affects the contrast of positive transparencies. The longer the development the higher the contrast and vice-versa. You should not forget in this connection that the exposure given needs to be adjusted to suit the development in mind. If you decide to curtail development to get a soft transparency the exposure should be slightly increased. Otherwise you will get a positive that is too light (too transparent).

Naturally the converse is also true, if you decide to prolong development you must reduce the exposure or the positive will be too dark (too opaque).

It is thus clear that it is quite feasible, using these two variable factors, exposure and development, to control to a certain extent both the density and the gradation of a positive transparency to suit yourself.

The development times given below are, therefore, only average times which can be modified within reasonable limits to suit your own methods of working.

The developer should be kept preferably at 68°F. (20°C.). Do not forget that lower temperatures will slow up the action of the developer and it will need, as a consequence, a longer time to act, conversely higher temperatures will accelerate development so that shorter developing times will suffice. Temperatures below 60°F. (15°C.) and above 75°F. (25°C.) are not advised.

★ Development times

At 65°F. (20°C.) in 'Metinol U' or formula G.251.

Material	*Time in minutes* *Tray**	*Development* *Tank†*
'Diapositive Normal' and Contrast Lantern Slide Plates	3–4	—
'Duplo Copy' positive film	4	5
Other 'Duplofilms'	4–6	5–8

*Tray development is with *continuous* agitation.

†Tank development – agitate for the first 30 seconds and thereafter for 5 seconds every 2 minutes.

Lantern slide plates are best tray-developed with constant agitation. Films are best developed in 35 mm. spiral tanks.

★ Important note

To ensure perfect positives each one ought to be developed separately, so that they can be given exactly the development required. This is unfortunately not a very practicable method if, for example, a long series of negatives are to be copied on positive film, as the film would then have to be cut up into a large number of pieces and each processed separately. This would take a lot of time and trouble.

Practical experience has fortunately shown that equally satisfactory slides can be made by printing a number of normal negatives one after the other on to a single strip of film and then developing this intact. It is desirable of course to find out the correct exposure required for each negative beforehand to give a well-exposed positive – after the standard development to be used. This exposure can be discovered for each negative by test exposures, which must be developed for the equivalent time to that intended for the complete strip of film.

Fixing, washing and drying

Films and plates should be rinsed in water quickly, between developing and fixing, or immersed for a few seconds in an acid stop bath (formula G.351).

Films and plates are fixed for 10–15 minutes in an acid fixing bath. 'Acidofix' acid fixing salt which is generally on sale is recommended for use in making up the fixer solution. If you wish to make it up yourself use formula G.301.

After fixing, films and plates should be washed for 30 minutes in running water or in at least 12 changes of fresh water. Place them to dry in a dust-free cupboard or location. Films can be hung up with pins or clips and plates stood on edge in a rack.

To prevent drying marks immerse the film or plate for 2 minutes after washing in a solution of 5–10 : 1,000 of 'Gevatol' wetting agent (in distilled or demineralized water). The water will run off more readily and evenly and drying will be more even and rapid.

Films and plates can, with advantage, be hardened before, during or after fixing.

BINDING LANTERN SLIDES

Although it is fairly tough the gelatine image layer is not hard and to preserve it from dirt, dust and scratches, it is usual to bind up a transparency between two thin pieces of glass held together by a narrow strip of gummed paper. The

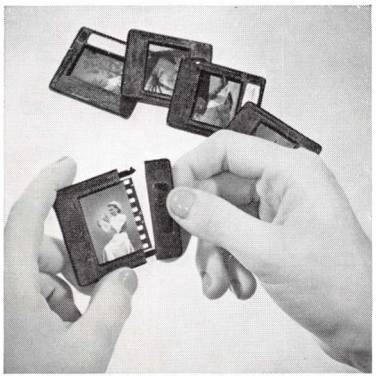


Fig. 86 Mounting a miniature transparency in a plastic slide frame

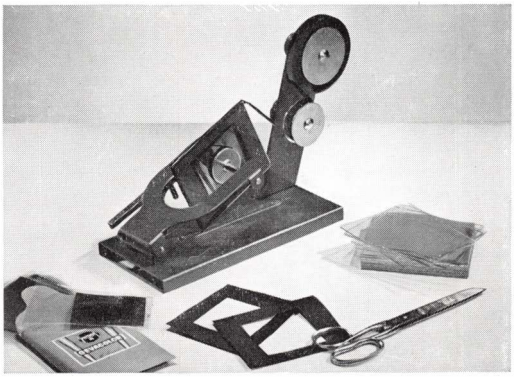


Fig. 87 Apparatus for binding larger sizes of slide.

narrow cellulose pressure sensitive tape is *not* recommended, as it oozes and collects dirt and is susceptible to heat, besides giving too airtight a seal which promotes internal condensation. Or they can be mounted in special mounting frames made of metal, plastic or cardboard. A large number of types and styles are available on the market at all prices, each with some special features or

advantages. If you wish to use any special type of slide changer on your projector, or an automatic projector, be careful to use a slide frame or glasses which will not jam in the projector.

The outer dimensions of the slide frame made for 35 mm. are 2 × 2 in. and the frame itself is provided with a mask that determines the area to be projected.

Special frames are available $2\frac{3}{4}$ in. square for mounting $2\frac{1}{4}$ in. square transparencies, but $2\frac{1}{4}$ in. square transparencies are often mounted with suitable masking in between $3\frac{1}{4}$ in. square (Britain) or $3\frac{1}{4} \times 4$ in. (American) glasses. The size of the mask, which can be cut from black paper with a razor blade, or can be made up of gummed paper strip such as is used to bind the slides with, is such that the image is positioned centrally on the slide, the outside of the mask being cut to the glass size. The mask can be lightly gummed in one or two positions to keep it in position. It is a good idea to leave the film free on at least two sides so that it can 'move' and 'breathe' slightly, otherwise it may 'cockle' in time.

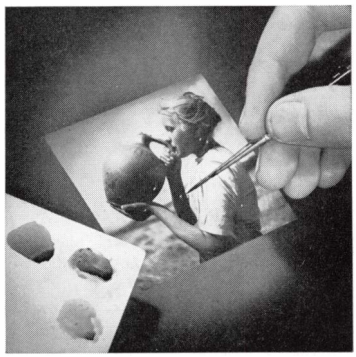


Fig. 88 Retouching a lantern slide.

Binding a glass lantern plate consists of covering up the gelatine layer with a flaw-free thin glass of the same size as the plate, fastening all round with gummed tape (see that the corners are finished neatly, any creases on the paper will cause jamming in the projector. A finished slide should be titled and spotted correctly according to the standard method laid down in each country. The British and American standards are identical: a white spot is placed in the bottom left-hand corner when the slide is held so that the image is upright and the correct way round).

It is advisable not to blacken by exposing to light any area of the slide which surrounds the image and which it is desired to be opaque. Since positive emulsions are very transparent this causes the exposure to spread inwards and to fog the edges of the clear image area. The surround should be printed clear unexposed and subsequently masked off before binding with black paper or gummed strip.

Many people prefer to use thin metal foil masks especially for 2 × 2 in. slides bound between glass. These reflect the heat and do not absorb it, as does black paper, in the projector. Further, whether bought ready cut or cut yourselves from metal foil sheets with a sharp razor blade, the edges of the mask are straight and clean and no loose fibres are left. As 2 × 2 in. slides are highly magnified on the screen, *anything* the slightest bit wrong shows up *greatly magnified.*

It is obviously necessary to get rid of all dust and to retouch transparencies, if necessary, before they are bound up. Dust can be removed with the aid of a flat soft sable brush. You will also need a magnifier and an illuminated box for

Photo: Stig T. Karlsson →



2 × 2 in. slides. You can also get rid of dust by gently blowing across the surface. Sometimes this is the best method to use as passing a brush too frequently over the surface will generate static electricity and *attract* dust. The glasses must also be cleaned. This also causes static electricity and attracts dust. There are now available 'Anti-Static pastes' marketed for polishing plastics but very effective in small quantities in preventing polished glasses from picking up dust.

Retouching is best carried out with a finely-pointed brush using special retouching watercolour paint, as made for use in the airbrush. These are available in a wide range of colours and can be equally well used for retouching black-and-white slides and colour transparencies.

For easy working use a small palette on which are laid out small spots of the colours required. To retouch simply touch the tip of the brush in water and take up a little colour from the palette. Obviously water dilutes the colour. If necessary several colours can be mixed to get the exact shade required. Apply the colour to the slide carefully and a little at a time, start with very little and build it up gradually until it is dark enough. Colour and density can be tested beforehand by viewing by transmitted light on a glass plate, or use a part of the clear border of the slide for this purpose. Colour is best applied nearly dry, if wet let it dry before further application. Build up larger spots or patches with a very fine stipple of small dots, any attempt to paint over large areas of gelatine will be disastrous.



PROJECTION

Projectors

A modern projector (for lantern slides) is shown diagrammatically in fig. 89.

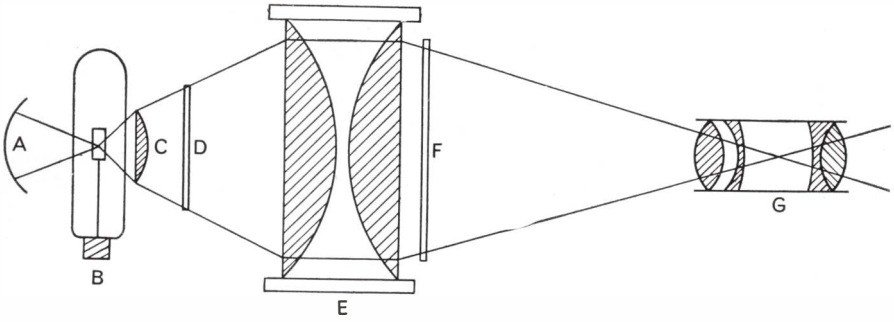


Fig. 89 Cross section – diagrammatic – of a slide projector
A=Concave mirror, B=Projection lamp, C=First condenser lens,
D=Heat filter, E=Double condenser, F=Slide carrier,
G=Projection lens.

The quality of the projected image is naturally the first thing to look at if you want to know how good a projector is. The projected image should be *bright* and perfectly *sharp* in the corners as well as in the centre; that is, of course, if the projection is being carried out in a suitable location and with a decent screen.

The *brightness* of the projected image depends on several factors, the most important of which are listed below:

- The transmission (average density) of the slide.
- The light output of the projector which depends on the wattage and type of lamp used and the aperture of the condenser and projection lens.
- The distance from projector to screen. The greater this distance the larger the picture on the screen but the darker the projected picture. Screen brightness $\propto$ (width of picture)^2.
- The general, ambient illumination which falls on the screen. The picture will appear brighter as the surroundings are darkened.
- The type of projection screen used. Near the projector lens axis a beaded screen will give much more light – about five times. Outside a certain angle away from this axis (about 45°) a matt white screen will have a higher reflectivity. A beaded screen is thus to be preferred in a long narrow hall where the spectators are seated close to the axis of projection. On the other hand a matt screen will be best in a wide room where the viewers are placed well to the side away from the axis. Beaded screens vary considerably these days in their properties and need to be used carefully to avoid creases and marks which *cannot* be removed. It is practically impossible to clean them of dust or

← *Photo: Jan Schiet*



Charles Morgan, M.A. – Photo : Howard Coster

dirt. Matt white screens do not show marks and creases easily and can be washed, brushed and resurfaced fairly easily. Always choose a smaller bright picture in preference to a large dull one.

The *sharpness* of the projected image depends among other things on –

– The sharpness of the slide itself. Miniature slides in particular need to be critically sharp to stand projection to large screen sizes. It should be noted that image contrast affects the apparent sharpness. A contrasty picture will generally appear to be sharper than a softer picture of much lower contrast.

– The quality of the projection lens and of all the optical system of the projector (we mean by 'all the optical system' the mirror, the condenser lenses, and the other parts of the light train. The correct separation of these elements is fixed within narrow limits).

Projecting

Only perfect slides will give a good projected image on the screen. Make sure to start with that your slides are above reproach if you want 100% perfect projection. This means you have to expose the negative correctly and then develop it carefully. Do not forget, however, that even a well-made slide projected by a good projector on a screen in good condition can give a poor result. We shall refer here to only one error on setting up the projector, and one that is easily remedied, but there are others which you should be on the look-out to avoid. It happens only too often that the pictures on the screen are either too bright or too dark. To obtain good projected pictures you must use a 'projection system' which is suitable for the job in hand and corresponds to certain standards (see B.S. : 1915 : 1952 or A.S.A. Z.38.7.14 : 1944).

Suppose you project (with a 2×2 in. projector) normally to give a picture that is about 5 ft. wide. Using an 8 cm. (3 in.) lens in conjunction with a 300 watt lamp the projector will need to be about 13 ft. from the screen. The projected picture will be bright because the projection distance and screen image size at this distance are well matched to the light output of your projector.

The brightness of the projected picture would, however, be much too low if you tried for instance to throw a picture 15 ft. wide in a large room with this same small projector and a 300 watt lamp. You would have to have in this case a larger projector with a 1,000 watt lamp.

The converse is also true. It is silly to use a 1,000 watt projector in a small room to give a picture 3 ft.–4 ft. across. Under these conditions normal slides would look far too light on the screen. A very much less powerful projector would do quite well in this case.

Where should the audience be?

The position of the spectators with respect to the screen is another matter that needs care.

The reflection from any screen is always at a maximum along the axis of projection and falls off as the viewer moves away to the side. In addition there



is a great deal of difference between the reflectivity of a beaded screen and of a matt white screen. For this reason it is best to place the audience, if possible,

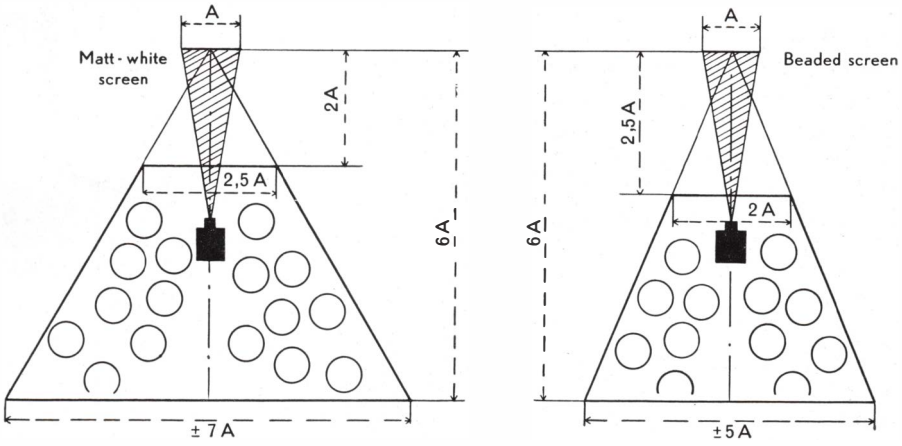


Fig. 90 Best positions for audience for beaded and matt screens. If you use a longer focal length lens you can project from the back of the room over the heads of your audience and so not get in their way. The projector and screen should not be inclined too much or the pictures will not be square. Do not put the screen too high or your audience will get stiff necks.

straight in front of the screen – without however putting them too close to it. The diagrams in fig. 90 give the best arrangement to adopt. Keep your audience inside the area outlined if possible. A=width of screen.

You will need a square screen on which to show slides since they may be horizontal or vertical format. Cine films on the other hand are always shown on a rectangular screen wider than it is tall.

★ Largest dimension of projected picture (in feet)

Projection distance	*Format 24×36 mm. (2″×2″)*				*2¼″ sq.*	*3¼″ sq. (3¼″×4″)*
	f=3″	*f=4″*	*f=6″*	*f=10″*	*f=6″*	*f=10″*
4 m.	176	140	92	56	144	130
6 m.	226	212	140	84	216	195
8 m.	356	284	188	112	288	265
10 m.	446	356	256	142	360	330
12 m.	536	428	284	270	432	400
14 m.	626	500	322	200	505	470
16 m.	617	572	380	225	585	535
18 m.	—	644	438	256	650	605
20 m.	—	716	476	285	722	670

← *Annigoni – Photo: Howard Coster*



A wedding in an Italian village – Photo : Toni del Tin

THE DARKROOM*

It is important that the arrangement of the darkroom should be both efficient and pleasing, whether it be for the professional photographer's use, for the developing and printing house or for an amateur. Obviously the installation required for a commercial or industrial photographer will be different from that of, say, a photofinisher's and this different again from that of an amateur who may be compelled to content himself with rather limited and makeshift facilities. Nevertheless, it is possible to lay down some general features which are essential, and these are given below.

GENERAL

A darkroom is, first and foremost, either a place where there is no daylight whatsoever, or which can be completely shut off from the light when necessary. The actual location chosen will determine exactly how the exclusion of extraneous light is to be achieved. The amateur who has no special darkroom accommodation will generally make do with a cupboard or a corner of the bathroom, of the attic or roof space, or of the cellar. The window can be blacked out with a venetian blind screen, a roller blind, or a permanent or removable screen of plywood, hardboard or cardboard, or a frame covered with black paper, or heavy dark canvas or tentage. The best and neatest method is to fit a hardboard capping frame round the window frame and to pull down an opaque spring roller blind. This is robust, quick, efficient, and leaves the window completely free when not in use. If the window can be permanently blocked each of the separate panes can be covered with opaque paper, preferably black, held in position by small wooden frames nailed to the crosspieces or wedged in firmly against the steel frame. Any cracks or chinks can be sealed over with gummed or masking paper. Cracks around doors can be covered with strips of felt or cloth or rubber or metal draught strip fastened properly around the door edge or to the jamb lining. The keyhole can be obscured by simply turning the key until it blocks the light.

Check that the blacking out is complete before you start to use a darkroom. The best way of doing this is to go inside and wait for 10–15 minutes for your eyes to become accommodated, after this the slightest light leak will be easily detected, only be careful to lower the head below bench level when looking around to make sure there are no leaks on a lower level.

In choosing a place for the darkroom the other factors to be considered are: the possibility of keeping roughly to the right temperature, the amount of humidity, and the ventilation available.

* By P. H. Germeys.

Obviously the ideal solution is to condition the air in every darkroom, the air then enters free of dust at the correct temperature and humidity. However, in most cases you will have to make do with something a little more 'primitive'.

Needless to say, central heating is the best way to keep the temperature constant. However, if this is not available, the room can be heated up quite adequately beforehand with a gas radiator, although the fumes make this unsuitable for a permanent darkroom, an electric fire or convector or better still a fan heater or enclosed electric pipes. In country districts a paraffin heater can be used, although these need careful control to prevent smoking. A coke stove is not advised as it causes too much dust as well as liberating sulphur dioxide into the room. If a stove which emits light is used, as distinct from the convector type, then to keep the temperature constant you will have to hold up your work at regular intervals to switch on the heater, and switch it off while handling negative material at least. It is better to avoid this if at all possible; there are many cheap heaters on the market which emit no light from the elements.

Remember however that, apart from personal comfort, the main thing is to keep the processing solutions at the correct chosen temperature; this can be readily achieved by placing trays and tanks on electrical hot plates, which can be thermostatically controlled, or by using suitably adapted immersion heaters. There are numerous types of both available on the market. If only a small amount of work is to be done then tanks can be placed in a water bath or, an even more simple solution, stood upon some heated bricks. In any case be careful to make sure that the containers used are not susceptible to heat. If they are to be stood on hot surfaces it is best to avoid plastic, except some of the hard heat resistant modern types, and to use glass, enamel, porcelain, or stainless steel trays and tanks.

Install any electric apparatus carefully to prevent short circuits and see there is a proper *earth* wire in every case; an electrical fault can have lethal consequences, especially in a damp location. If possible have a qualified electrician test the insulation of all your devices with a 'megger' at least once a year.

Of course it is quite possible for the ambient temperature to be too high, for instance in the tropics. It is not so easy in these cases to get it down to normal unless, of course, the premises are air-conditioned. Under these conditions it is best to use special formulae for developer, fixer and hardener (see Part V). If the temperature tends to rise too high in temperate zones the processing solutions can be cooled down by standing them in a water bath using cold tap water or cubes of ice.

To ventilate a darkroom you can, according to its size, install one or more louvred ventilators which admit air but not light: one close to the floor to let in fresh cold air, a second close to the ceiling to let out the warm stale air. To keep out the dust you can stretch out a piece of gauze or fine butter muslin over the entrance hole. Alternatively a fan can be used for forced ventilation, and a number of special adapted darkroom types are available, some with speed control, and some which provide a two way in and out flow with a single fan, can be easily installed in a single window pane ('Vent-Axia').

Street Scene in Orleans – Photo: Elliott Erwitt →

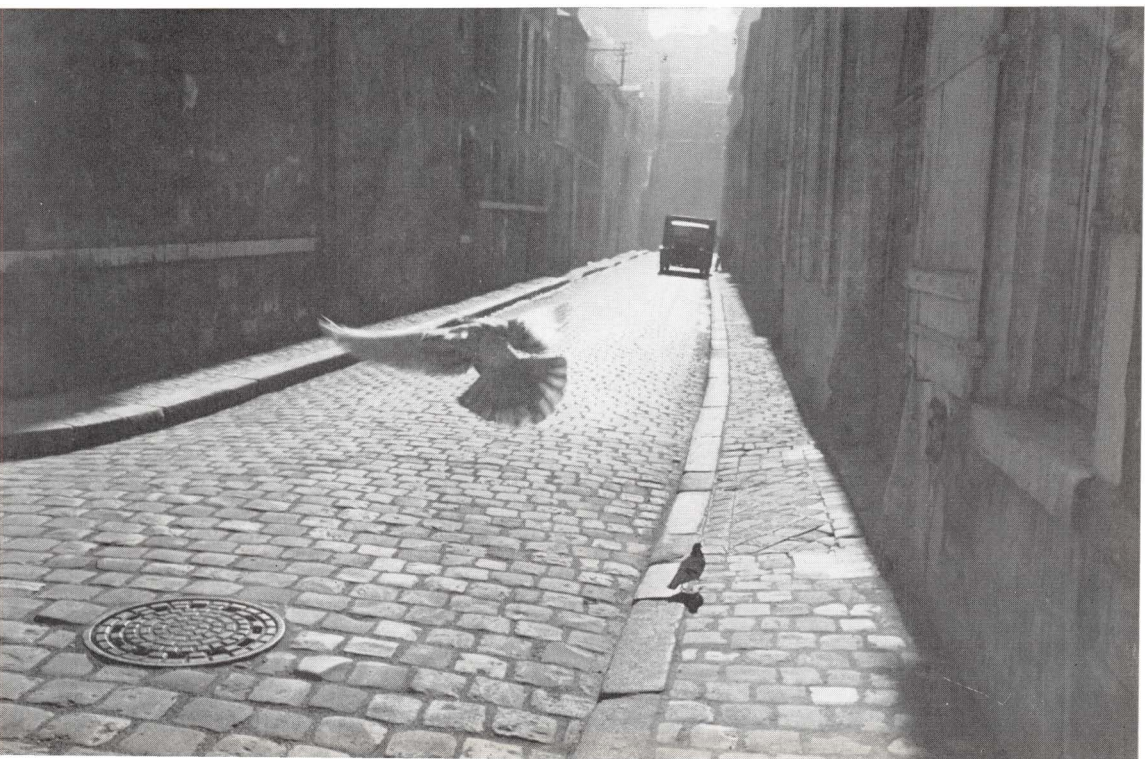
Electricity, as will be readily acknowledged, is practically indispensable in a modern darkroom. Running water is likewise highly desirable, both hot and cold. The wash water should be kept at constant temperature by a thermostatic control, of which there are a number commercially available, although none works really well without additional pressure and heating controls in the system. A water heater (preferably electric) will be needed for making up chemicals which require hot water for the purpose.

The amateur who for one reason or another cannot provide himself with a special place for his darkroom and must make use of a location normally used for another purpcse should pay particular attention to the following facts:

A bathroom is generally fairly free from dust, but relatively humid, so do not store dry chemicals, sensitive photographic materials or negatives there; be sensible enough to store these away in a cupboard which is kept in or near a dry place, such as a landing or passage. All the same, a bathroom is a convenient place to make use of because it has running water, which can be made hot, and is most convenient for all the wet operations of processing.

An attic (or roof space) or a cellar are generally rather dusty and an attic is also very susceptible to variations in outside temperature, so that the processing solutions have to be heated up fairly frequently. Running water is not generally available nor are drains. Cellars are generally damp but the temperature there is fairly constant, cool in summer, and warmer than outside in winter. Photographic material should not be stored in either location.

It is advisable to cover enlargers and similar apparatus with a dust cover, or one of plastic cloth, in an improvised darkroom. In addition in a damp location it is a good idea to put inside the cover a small amount of a drying agent (silica-gel for instance) tied up in a small cloth bag.



Some amateurs fit up all their apparatus and store their photographic material in a cupboard or chest which can be mounted on castors or wheels so that it can be wheeled away into a corner of the room or on to a corner of the landing, or so that it can be used as a side table in a pantry, and so on. If they then want to develop a film they just wheel it complete into the darkroom, unpack it and everything is immediately to hand. If he follows the general instructions given here as to what is required in a darkroom the resourceful amateur will be able to decide what he wants to stow away in his own particular trolley and the particular arrangement that he prefers to suit his own method of work.

THE CONSTRUCTION

The floor

The darkroom floor should be watertight; it should resist the action of acids and warm chemicals. It should not be slippery whether dry or wet. The colour should be fast and it should be easy to clean. Ceramic tiles are often used, but in recent years the comfort of plastic and rubber tiles is generally preferred. Sheet rubber, polyvinyl chloride and linoleum are all useful, especially if they are cemented down so that there are no cracks, joints or seams to let water through. If an open drain or gulley has been provided the floor can be cleaned with water spray and a sponge mop or squeegee. A vacuum cleaner can also be of considerable use.

The walls

The material of which the walls are made is not of great importance because, as a rule, very little chemicals will be spilt or splashed on to them. Smooth finishes are to be preferred as they are easy to keep clean, glazed ceramic tiles again are very suitable. Rough brick should be rendered with plaster or some suitable binder. The best colour for the walls has been over-much discussed; there is no need to choose a dark shade – quite the contrary – let alone plain black; provided that the safelight is kept at the correct distance away from the tranks or trays.

Bright colours are not advisable because they reflect every little beam of stray light and may fog sensitive emulsions. Clear pastel shades in the modern manner are very suitable.

The entrance

Now let us consider how to get in and out of the darkroom. We want to stop white light entering the darkroom every time we come out or go in. To do this we need a maze or safety lock. The type used depends on (1) the available space, (2) the traffic through the entrance, i.e. entering and leaving, or only one of these, (3) how often the darkroom is in use and how many people are using it at the same time.

Fig. 95 shows several practicable schemes. The inside walls should be painted a dark colour – matt black for instance – although it is wise to paint a narrow

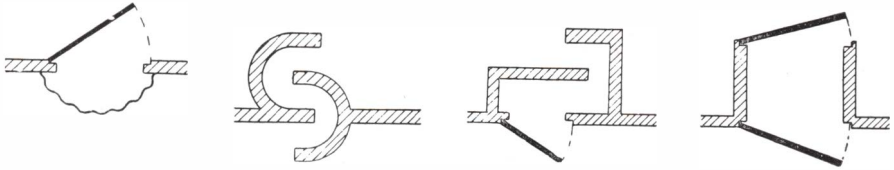


Fig. 95 Light trapped entrances for darkrooms.

horizontal white line at eye level to prevent anyone accidentally walking into the wall – to prevent unwanted reflections, and the floor outside should also be a dark colour or much light will be reflected obliquely upwards through the maze. An alternative arrangement, unnecessary with a single-handed worker, is to provide a safety interlock which prevents both doors being opened at the same time. A red light or a warning buzzer can also be installed on the outside of the pass door to indicate that entrance to the darkroom is forbidden.

LAYOUT

The layout of a darkroom is essentially based on a division into two main areas: a 'dry' bench and a 'wet' bench. The first is for handling sensitive materials as long as they are dry, and later on for finishing photographs; the 'wet' bench holds all the various trays and tanks and also the washer – although drying and subsequent operations (sorting, numbering, trimming, putting into bags, etc.) should preferably be carried out in a separate place in normal daylight.

The wet and dry benches should be kept quite separate from each other and so far apart that splashes of water or liquid chemicals cannot possibly reach the dry bench top and so cause spots. If this is not possible then they should be separated by a sizeable partition. Their precise position depends of course both on the shape of the room available and the way the work is to be done. To speed things up the successive operations should be arranged in order, the first near the entrance, the last near the exit of the darkroom. A clockwise or anti-clockwise fixed sequence of operations can also be adopted round the room and so economize in the amount of walking to and fro. This type of organization is particularly useful in rooms where several people are working at the same time, and will be found to increase output.

Professionals generally have to process films, plates and papers at one and the same time, and naturally find it best to have two separate workrooms, one for negative work, for developing films and plates, the other(s) for printing where contact prints and enlargements are made. Each of these darkrooms will have its dry and wet sides.

The 'dry' bench

This bench houses all the material and apparatus necessary for handling films, plates and paper before it goes to the developer. Any sizeable laboratory will find it best to keep a special 'loading bay' where plateholders, cassettes, etc., and

working stocks of sensitive negative materials are kept, well away from the processing rooms. These, of necessity, must house the hangers, spools and clips that are used to hold film and plates during development. The scheme in fig. 96 shows how the layout of the various items in a printing room can be arranged.

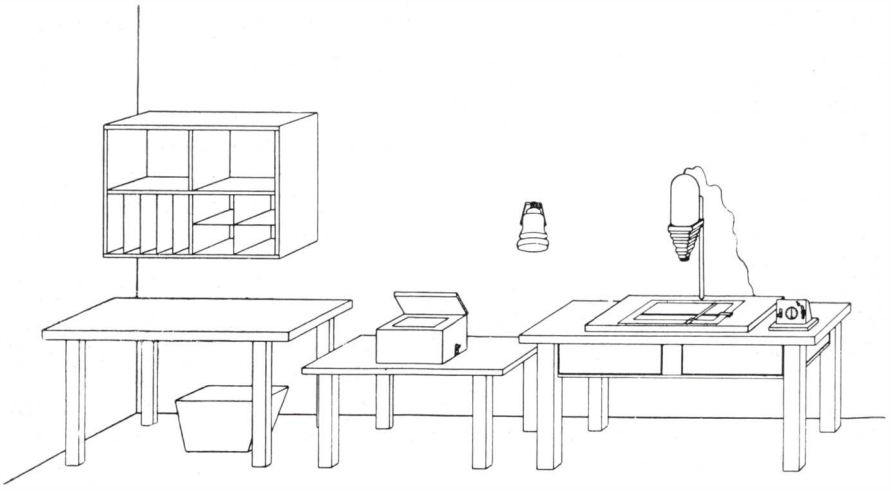


Fig. 96 Diagram showing arrangement of various pieces of equipment in a printing room. From left to right: the workbench with paper hopper, cupboard for storage of paper stocks, contact printer, safelight, enlarger and electric interval timer.

The work bench should have a top covered with lino, varnished teak, or a plastic protective layer which is impervious and acid and alkali resistant (veneered blockboards and plywoods are suitable provided they are finished with a hard setting plastic film of the phenolic resin or epoxy-resin type). Above the table there should be a cupboard with compartments to hold a small stock of reserve paper and the usual useful items such as safelight screens, printing frames and boxes, etc. A weak white light, adequately shaded, can be fitted *under* the cupboard to illuminate the area. Be sure to leave sufficient room somewhere or other for the negatives which are to be printed and the paper, keeping the unexposed paper on the right, and exposed paper on the left, stacked emulsion face-down in a box slightly larger than the paper size.

The enlarger is stood on a firm table provided with two light-tight drawers, one for unused paper, and the other for exposed. The same type of drawer can, of course, be placed under the contact printer. If the enlarger is not equipped with an automatic exposure timer then a foot-switch should be provided so that both hands are free during the exposure and can be used for 'shading' or 'holding back' certain areas of the print. Foot-switches can be purchased from trade suppliers, or are easily enough made. The exposure time is regulated by reference to a darkroom clock, or a metronome or some such device. Useful accessories for enlarging that are worth mentioning are a paper holder or enlarging

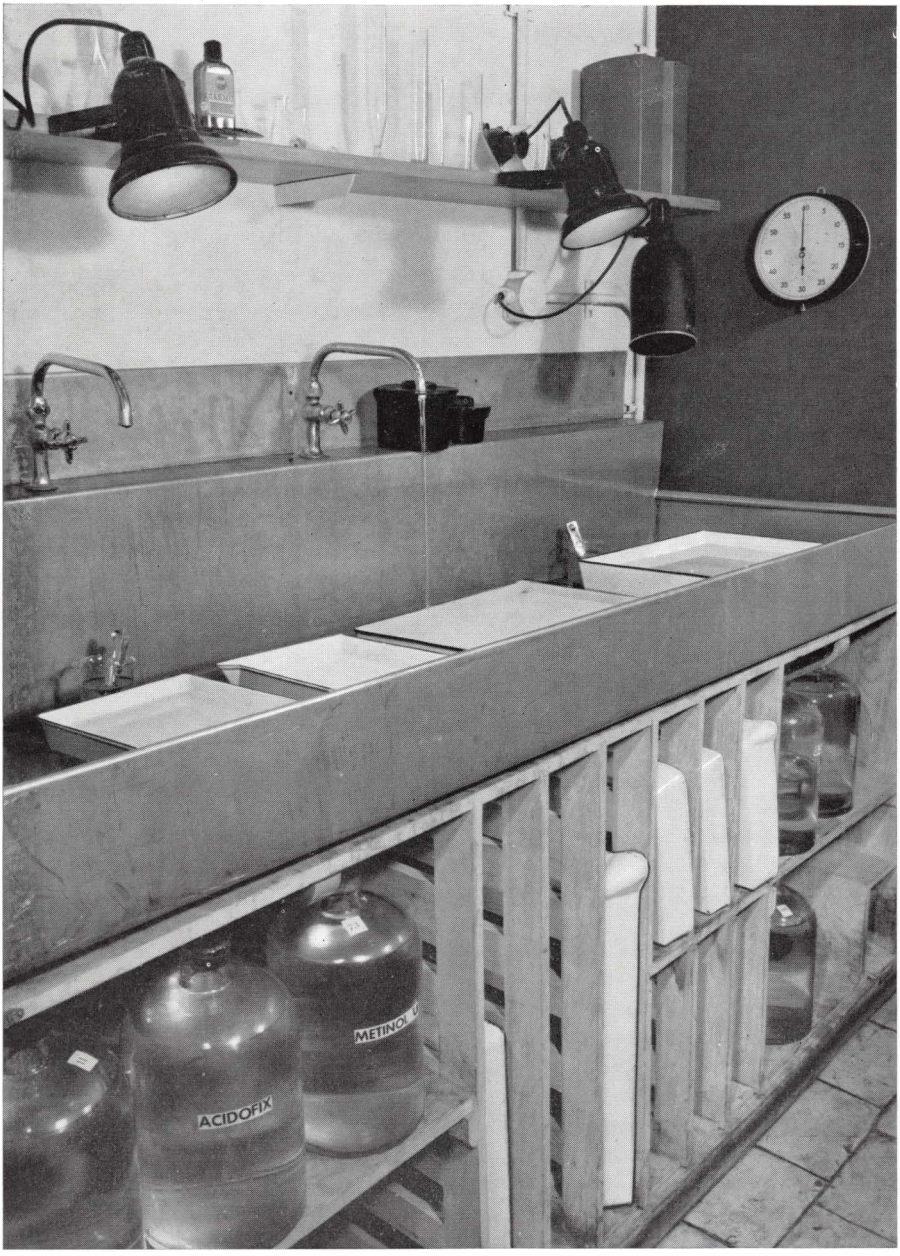


Fig. 97 Typical wet bench installation in a printing or enlarging room.

easel with adjustable borders to hold the paper exactly in position on the baseboard and to give the desired pre-set white margins, a set of 'dodgers' made of pieces of card cut from reject prints to be used for 'holding back' or printing in certain areas of the negative, a so-called 'test' negative to help focus and frame up, a magnifier to help get the image sharp, scissors to cut test strips, a soft camel hair brush for keeping the lens and negatives dusted off, a negative holder and masks, etc. When not in use these items are stowed away in the cupboard.

Keep a small clear place next to the baseboard of the enlarger to take the negative holder when the negative is being inserted. A waste bin, and one or more darkroom lamps with a selection of safelight screens (filters) complete the equipment of the 'dry side'. The height of the various surfaces and tables is fixed according to whether the work is carried out standing or sitting down.

The 'wet' bench

As has already been pointed out all the tanks and dishes used for processing films, plates and papers are kept on the wet bench. Normally it consists of a large sink up to about 12 in. in depth, at table height, on which are placed the different tanks. The sink must be made of impervious material, and must be resistant to heat, acids, and the chemical being used. The construction should be solid and stable, and easy to keep clean. Stainless steel is much used, because it is relatively easily shaped and is relatively light (or a framing of hardwood can be covered with a lining of lead with 'burnt-in seams', or lined with bitumen, or coated with a plastic resin, with a catalyst hardener, or a lining of welded alkathene or polyvinyl sheeting). Older sinks were sometimes made of stone or slate slabs, glazed tiles or teak cramped together with metal ties and bands.

Fig. 97 shows a suitable arrangement of the wet side of a printing room. The sink has a slightly inclined floor and is fitted with a wooden grid or lattice so that liquids can run away quickly to the drain. The various necessary trays are arranged from left to right in the order in which they will be used: developer, stop bath, fresh water, one or two fixing trays, and a tray or tank for washing. Behind each tray is placed a small container to hold the forceps or tongs used in each tray. The wall behind is faced up to a height of about 16 in. with a chemically resistant material to protect it from splashes, etc. A darkroom clock (seconds and minutes) is placed in the handiest place and a number of darkroom lamps, varying according to the length of the bench, are also provided. Above the tray of wash water is placed the weak 'white' light shining downwards for the examination of the finished wet prints. This lamp may well be operated by a foot switch for convenience. Glass graduates and measures, test tubes, funnels, thermometers, safelight filters, etc., can be kept on a narrow shelf.

The space under the sinks can be used for storing made-up stock solutions and for trays and tanks for negative development when there is not a separate room for this work. Racks to hold trays should be movable so that they can be pulled out for periodic cleaning. When work is in progress these racks can be

Photo: Herbert Friemel→

used to hold the floating lids and lids used on developer tanks to prevent oxidation of developer and to cover up fixing tanks, etc. Be careful to wash them thoroughly before you stow them there, or in a few days you will be in a terrible mess. The wet bench ought also to have a suitable place for dispensing solutions. A fairly low table with a marble or stainless steel top or a similar material will do. As a general rule dry chemicals should not be mixed up in the darkroom, especially a negative room, and some other location should always be found for keeping the dry chemicals and for weighing them out and dissolving them. If no other suitable location is available then you will be well advised to make use of pre-packed liquid developers and fixers exclusively. A cupboard or set of shelves will be required for mixing vessels (beakers or flasks), the scales and measures, etc., necessary for making up solutions. The dry chemicals, in suitable containers, may also be stored there if it is a suitable dry place. Be careful to lock away all poisons and acids where children cannot possibly get at them, or they cannot be accidentally damaged or broken. Do not place containers of acid or corrosive on high shelves where they may tip over when reached for. Be careful that the floor is not slippery where chemicals are carried. Forethought and care will prevent serious accidents.

It is a good idea to place the wet bench at a distance from the wall. This will give plenty of room for the water and electricity pipes and they will be easy to

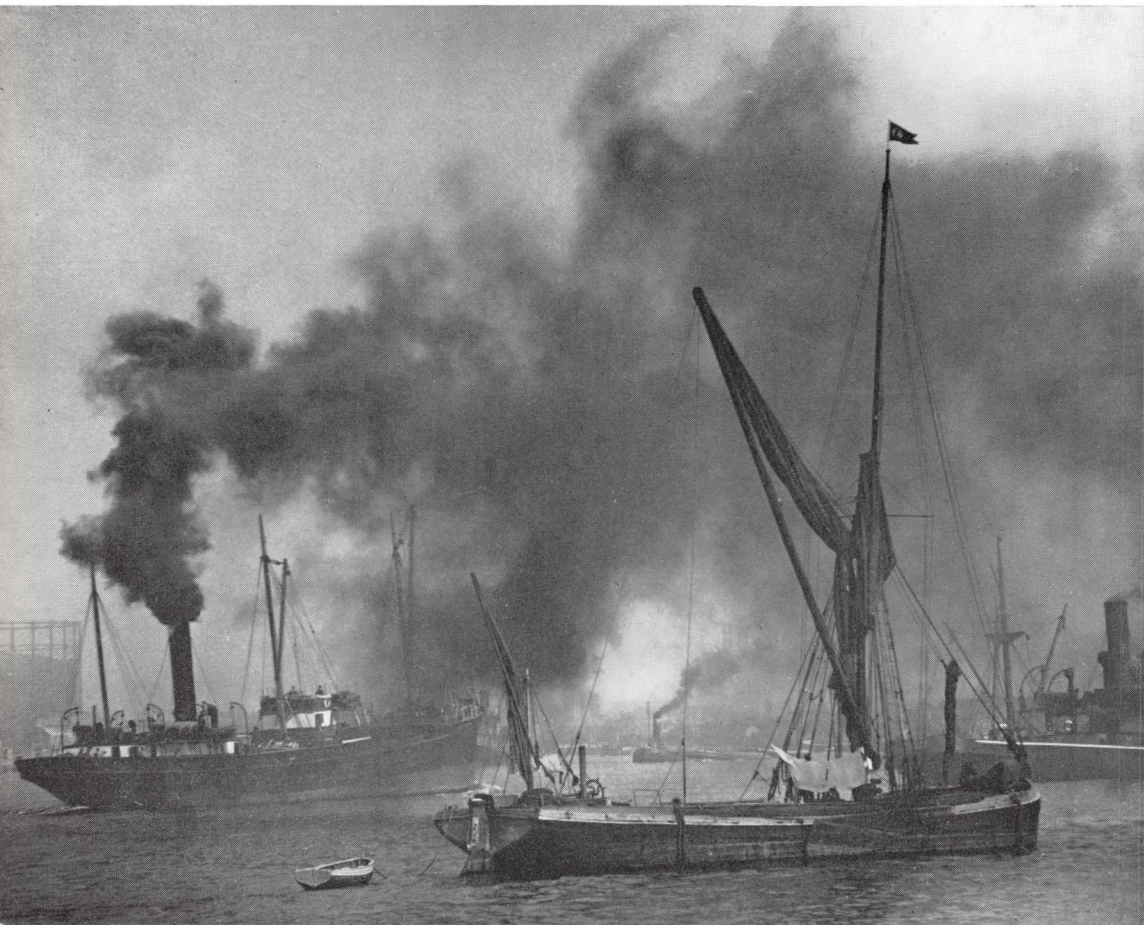


get at if any repairs are necessary. Toe room should be provided underneath the front face of the bench, this will make working much more comfortable. Roller or hand towels should be hung up within easy reach of where they will be most needed, i.e. near the developer, fixing and washing tanks or dishes. Do not forget to change them frequently.

Illumination of the darkroom

When handling any light sensitive materials due regard must be paid to both their general sensitivity and to their particular colour sensitivity. They must therefore be handled in darkroom illumination which has no effect upon the material in question, and in the case of high speed panchromatic negative films in total darkness.

For convenience in working, the darkroom should be provided with overall general non-actinic lighting and in addition to this a number of additional local safelights should be fitted over the work benches or sinks. The first type of illumination is provided by indirect safelight lamps (there are many types on sale) which are hung from the ceiling near the centre of the room, or distributed evenly over the ceiling of a larger room, close enough to it to give a soft diffused light which has no effect on the emulsion being handled, provided of course that this is matched in sensitivity to the safelight screens (filters) in use. Ordinary



white light illumination is, of course, also provided. To prevent mishaps it is wise to separate the switches – controlling the two sorts of lighting. The white light switch is best raised well above the normal level and turned through 90°, or provided with a special spring clip cover, to provoke thought when it has to be used.

The 'bench lights' are placed over the important work areas: e.g. near the contact printer or enlarger baseboard, over the developer dish and the fixer. It is a good idea to place over the end of the wet bench, where prints, slides or negatives are washed, a source of white light, rather weak (5 watts), shining downwards so that the finished prints can be examined. Suitable lamps are available commercially, or one can be made by boxing in an ordinary reflector light with a piece of cardboard with a small hole or a narrow tube to narrow down the beam so that it shines only where it is required.

To help judging and preparing negatives it is useful to provide a weak white light behind an opal set on the bench near the enlarger.

We can use, to illuminate the darkroom, either bulbs with special coloured glass envelopes or ordinary clear or opal glass bulbs fitted into special safelight lamps into which are slid filters or screens. The second method is more flexible and economical.

★ 'Gevinac' filters

Gevaert supply 'Gevinac' darkroom safelight screens for use in most makes of darkroom lamps. They are made up of a sheet of clear or opal glass on which is coated a coloured gelatine layer to absorb the actinic light, this being covered by a sheet of clear glass.

They are sold in a variety of colours each suitable for handling a given class of sensitive materials, in the following range of sizes:

9×12 cm.		5×7 in.
13×18 cm.	18×24 cm.	8×10 in.
16×21 cm.	20×25 cm.	10×12 in.

They have a thickness of between 3·5 and 4 mm. (approx. 5/32 in.).

No.	*Colour*	*Used for*
L 501	Yellow	'Ridax' and Lippmann emulsions
L 552	Orange	Other contact papers
L 611	Light red	Non-colour sensitized (blue sensitive) emulsions
L 612	Red	Non-colour sensitized (blue sensitive) emulsions
L 652	Dark red	Orthochromatic emulsions
X 535	Dark green	Panchromatic emulsions
X 572	Yellow-green	Enlarging papers
X 592	Dark yellow	'Gevacolor' Positive film and 'Gevacolor' paper
D.2	Dark yellow	'Gevacolor' Positive film and 'Gevacolor' paper. Only for use with a 15-watt sodium lamp

The correct filters recommended for handling Gevaert materials, under 'normal' working conditions, are given below:

← *Busy Thames – Photo: H. A. Murch*

By normal working conditions is meant:
(*a*) The use of a domestic type electric bulb of 15 watts at its rated voltage or below, or a 15-watt sodium lamp with filter D.2.
(*b*) A distance between safelight and sensitive material of about 2 ft.
(*c*) Material exposed for a reasonable time.

★ Films and Plates

'Dia-Direct 26 Pan Reversal'	X 535	dark green
'Duplo Copy'	L 611	light red
'Duplo Ortho'	L 652	dark red
'Duplo Pan'	X 535	dark green
'Duplo Pan Rapid'	X 535	dark green
'Gevachrome 32'	L 652	dark red
'Gevapan 27'	X 535	dark green
'Gevapan 30'	X 535	dark green
'Gevapan 33'	X 535	dark green
'Gevapan 36'	X 535	dark green
'Replica 23'	L 652	dark red

★ Papers

'Artona'	L 552	orange
'Gevacolor'	D.2	dark yellow
	X 592	dark yellow
'Gevarto'	X 572	yellow-green
'Gevatone'	X 572	yellow-green
'Gevabrom'	X 572	yellow-green
'Ridax'	L 501	yellow
'Vittex'	X 572	yellow-green

It is easy enough where necessary to discover for yourself whether any particular illumination is sufficiently safe for the job in hand. To do this place a sample of the film, plate or paper to be used on the bench or table where it will normally be handled, and turn on the safelight. Cover a part of the test piece with something opaque (a coin will do) or a piece of black paper. Leave the sample piece exposed to the normal illumination from the safelight for at least *twice* the time that it will be exposed during handling in the darkroom, i.e. twice the developing time if it is to be developed in the full illumination of the safelight. Then put out all the lights, develop for twice the normal time and then fix. That part of the sample which was covered up during the test will be completely clear or white. If the other part is fogged, even faintly, then the safelight illumination is not sufficiently inactinic. This can be corrected by using a lower wattage bulb, a darker safelight filter, or by increasing the distance from safelight to the working surface and sensitive material.

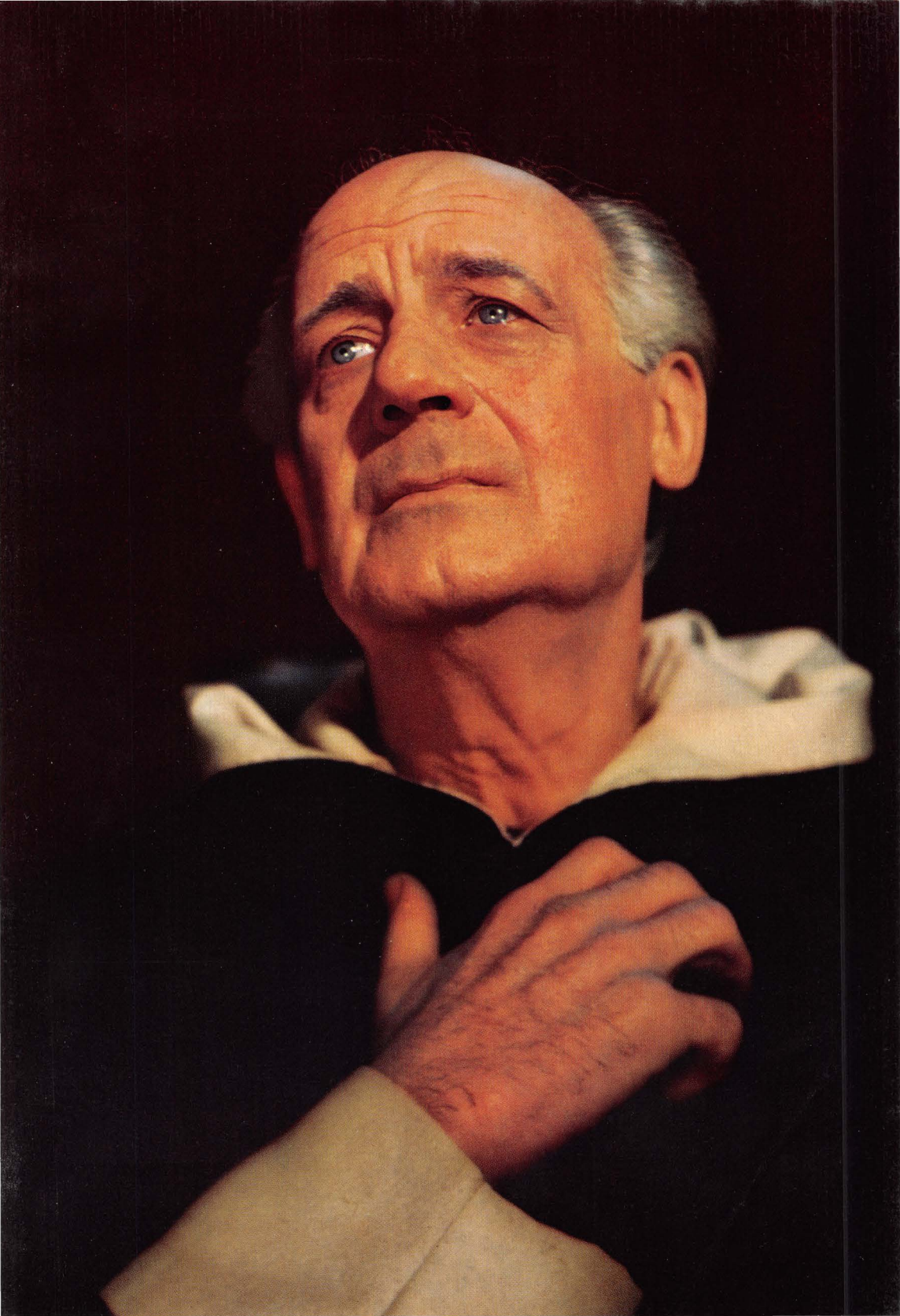
You will be well advised to ensure, when the lighting and electrical installation is carried out in the darkroom, that all the wiring is carried in metal conduit and properly earthed, and that all the switches used are the types approved for use in bathrooms or wet locations (i.e. cord pull switches, etc.). This will prevent any short circuits or shocks which might be caused by handling them with wet or damp hands.

PART FOUR

COLOUR PHOTOGRAPHY

Short History
Processes
'Gevacolor'

Gevacolor Reversal Photo: O. Civirani
'Still' from the film 'Joan at the Stake' of Roberto Rosselini →





Gevacolor Negative
Photo Cavoukian

COLOUR IN PHOTOGRAPHY

The enthusiasm with which the invention of Nièpce & Daguerre was greeted over one hundred years ago did not blind their contemporaries altogether to the fact that their pictures lacked one essential feature: colour. This lack was felt all the more acutely because many of the first photographers were also artists and painters. It is, therefore, hardly surprising that inventors have, ever since the beginning of photography, devoted prodigious efforts to try to capture on the sensitive layer this elusive characteristic of the image which shows on the ground glass and is then lost in the photograph.

Colour photography these days gives excellent results, full of promise for the future. It is safe to say that it will come as time goes on more and more into everyday use.

SHORT HISTORY

Numerous inventors have, during the past century, made their distinctive contributions to colour photography, and produced brilliant ideas which were, however, impossible to realize in practice in their own day because they depended on other discoveries which had yet to be made. Nevertheless some of them were able to achieve remarkable practical results.

Here is a short list of those who have blazed the trail in the long series of discoveries which continues today:

J. Seebeck discovered, in 1810, that silver chloride exposed to coloured light became the same colour as the light used.

A. Becquerel made use of this property in 1848 to obtain coloured pictures of the solar spectrum on chlorided silver plates, which he was, however, unable to fix.

Cl. Maxwell demonstrated experimentally in 1861 that it was possible by the use of photographic images in three suitably selected primary colours to recreate for the eye all the colours of a natural subject.

Ducos du Hauron published in 1868 and the years following the results of his experiments on colour photography by three-colour synthesis. He put forward extremely ingenious and complete ideas on the problems involved.

Vogel in 1871 discovered optical sensitizers (dyes) which allowed emulsions sensitive to all the colours of the spectrum to be made.

Lippmann in 1891 made excellent colour photographs by exposing transparent grainless emulsions in contact with a layer of mercury which acted as a mirror. This formed, by interference, 'standing waves' which were recorded in (the

depth of) the sensitive emulsion layer and which (after processing) could be used to reconstitute by reflected light all the colours of the spectrum *accurately* and *completely*.

A. & L. Lumière invented the Autochrome plate in 1904.

Fischer and Siegrist conceived in 1911 *chromogenic* development – the basic method used in all modern subtractive processes of colour photography.

Becquerel, Lippmann and others not mentioned above sought to reproduce directly without change all the colours of nature. The great majority of other workers have used the *trichromatic* method, i.e. they have tried to reproduce all the natural colours by means of three so-called *primary* colours mixed together in varying proportions.

We are only concerned here with three-colour methods which are the only methods used in practice today. It is worth noting incidentally that attempts have been made from time to time to convey more or less the impressions of natural colour by the use of only two primaries, that is by a two-colour, a *bichromatic* system.

LIGHT AND COLOUR

As Newton first showed, white light, which is made up of all the different radiations to which our eyes are sensitive, can, we know, be split up by means of a prism into a whole range of different *colours*: those that we see in a rainbow (see fig. 100A). Although the rainbow contains a very large number of hues – which can be made to yield more by mixing them together – it is possible to state that as far as the human eye is concerned, all these hues (colours) can be recreated in a satisfactory manner by the appropriate mixture of three colours: *blue*, *green* and *red*. These three colours are named primaries.

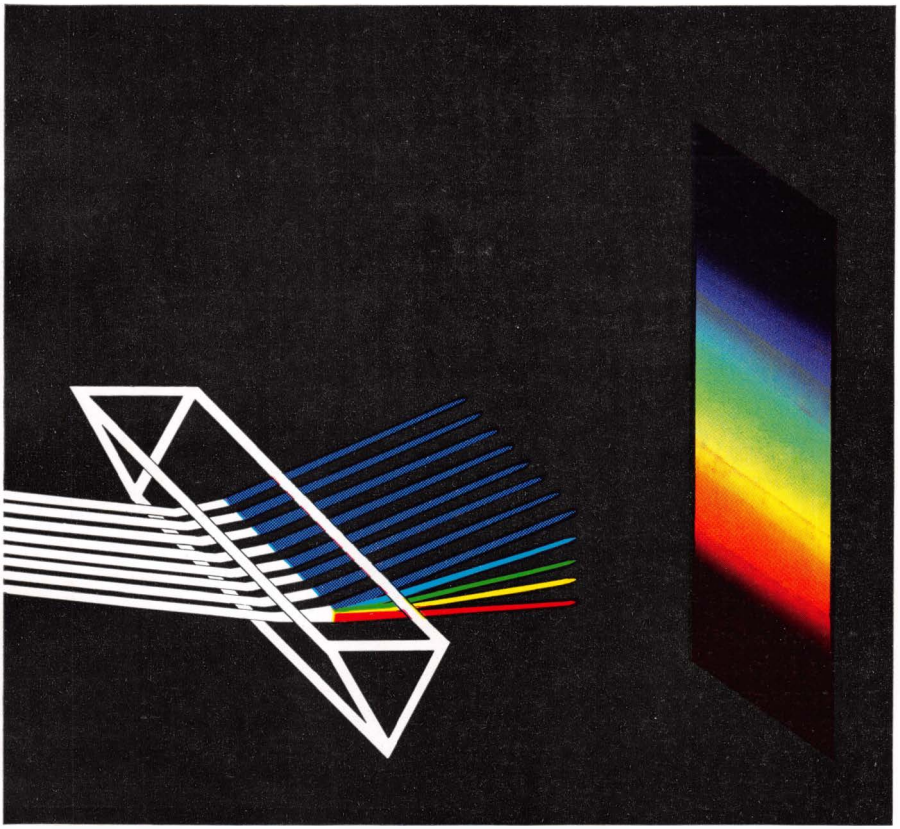
If, as Maxwell himself showed, we throw with three projectors three beams of light coloured, respectively, blue, green and red on to a white screen in a darkened room the mixture of these three colours in equal proportions will give white (see fig. 102A).

Fig. 100 The spectrum →

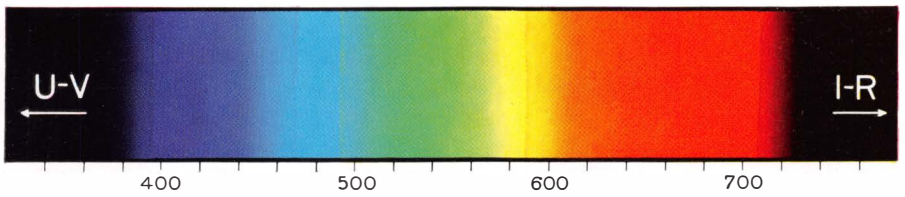
A. Splitting up of white light by means of a prism.

B. Spectrum of white light with corresponding wavelength scale underneath.
Note: In nature pure spectral colours never occur, colours in general are composed of a relatively wide band of the spectrum. Yellow is a particular case in point: yellow objects reflect practically all the colours with wavelengths between 500mμ and 700mμ. Yellow therefore is in practice a mixture of red and green light (see *diagram of three-colour projection, p. 342*).

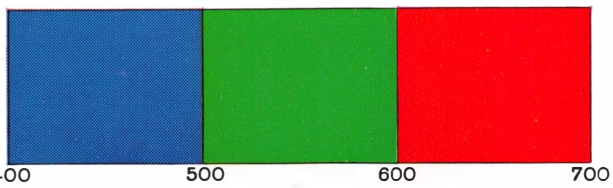
C. In colour photography light of different wavelengths between 400mμ and 500mμ is considered to be blue, between 500mμ and 600mμ green, and between 600mμ and 700mμ red. Mixtures of different amounts of these three colours give all the other colours.



A



B



C

Mixing equal quantities of light of each pair of primaries gives the following results:

Blue + Green = Blue-green (cyan).
Blue + Red = Magenta (purple).
Green + Red = Yellow.

These results are very different from the colours obtained when coloured oil paints or pigments are mixed together, but more of this later.

Complementary colours

Two colours are said to be complementary to each other when they give white light when mixed together (in the form of light beams). The following table gives the complementary colours to the three primaries.

Primary colour	*Complementary colour*
Blue	Yellow (=green and red).
Green	Magenta (=red and blue).
Red	Cyan (=blue and green).

The three complementary colours, yellow, magenta and cyan, play an important part in (modern) colour photography as will be seen later.

Wavelength

Comparisons can readily be made between light waves, radio waves, sound waves, and waves formed when a stone is thrown into a pond.

Light is composed of waves which travel with a speed of 300,000 km./sec. The wavelength can be measured with extraordinary precision.

The wavelength varies with the colour of the different parts of the spectrum and is shown in fig. 100B. The figures represent (mμ) millimicrons – i.e. millionths of a metre (or thousandths of a millimetre). In colour photography the visible spectrum is divided roughly into the three following parts, remembering what has been said about the three primary colours:

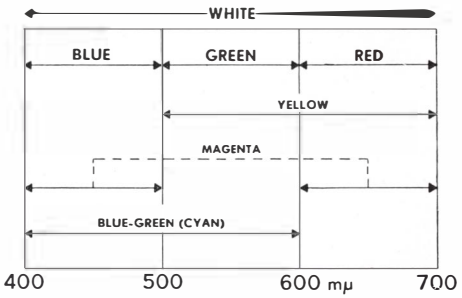


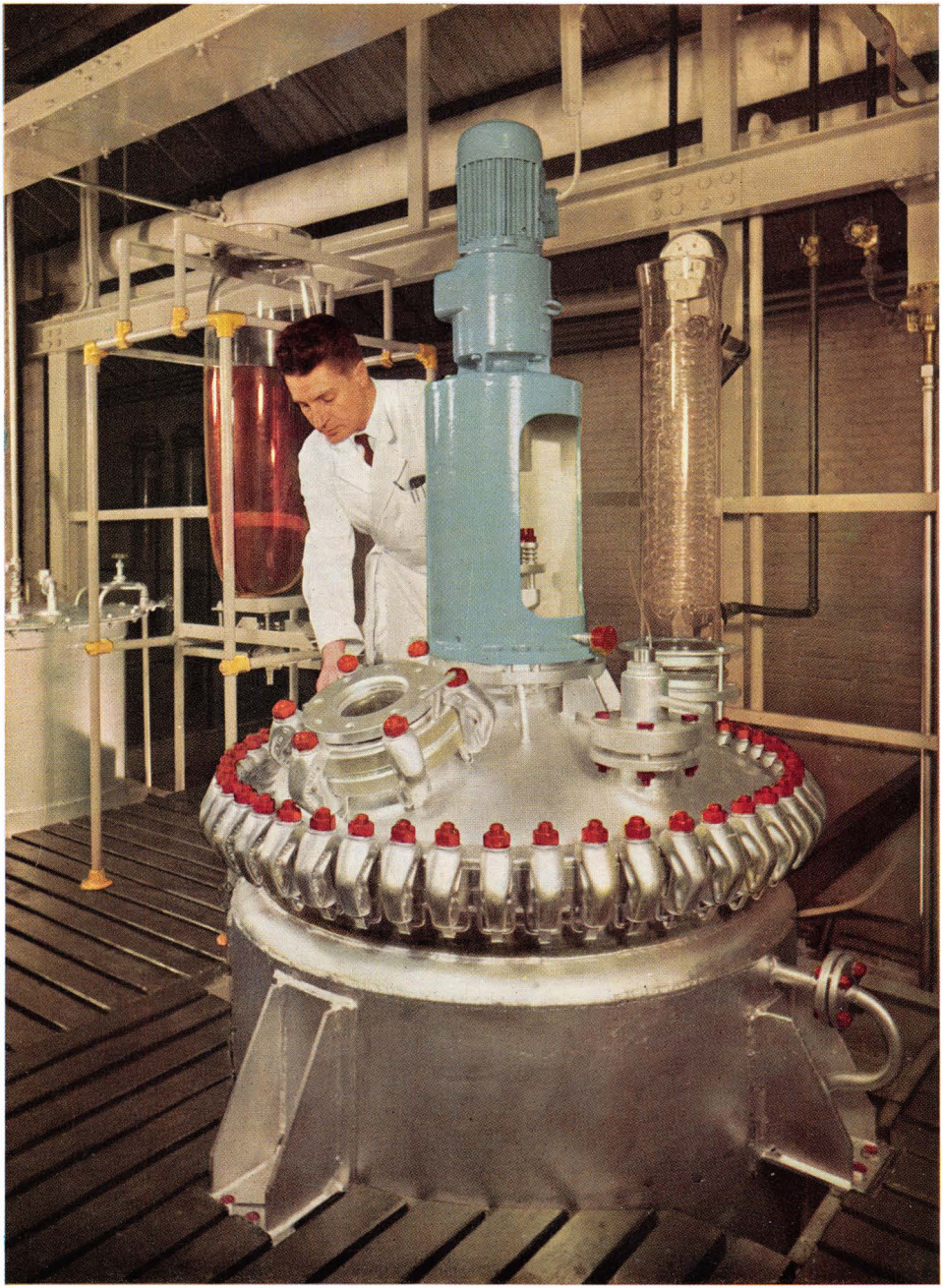
Fig. 101 Wavelengths in mμ.

Blue = all light with wavelengths between 400 and 500 mμ.
Green = ,, ,, ,, ,, 500 and 600 mμ.
Red = ,, ,, ,, ,, 600 and 700 mμ.

This is shown diagrammatically in fig. 101.



Gevacolor Reversal
Photo Hans L. Pillat



Gevacolor Negative
Photo J. Mees

It is worthwhile memorizing this diagram not only to understand colour photography but also for other photographic problems such as coloured filters, etc.

Note that in some publications wavelengths are given in Angstroms or angstrom units (Å) which are 1/10th of a mμ. The wavelength number when given in these units always has an extra 0 on the end.

Additive and subtractive colour mixtures

As we have already seen the superimposing of *coloured light*, e.g. beams from projectors, gives the following colours:

Blue and green = Cyan.
Blue and red = Magenta.
Green and red = Yellow.

These are called *additive mixtures* because one coloured light is added to another.

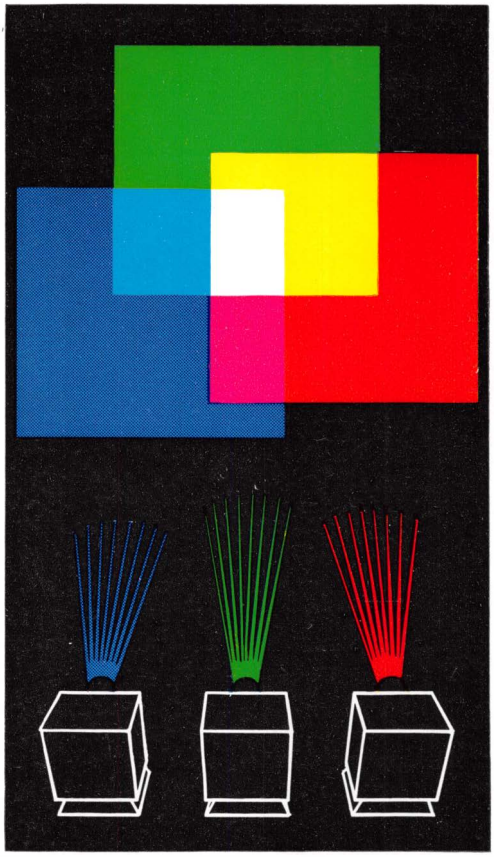
The colours obtained in this way (yellow particularly) would be something of a surprise to anyone used to mixing say oil colours for painting. Mixing beams of coloured light and mixing 'pigments' are, however, very different operations. The separate effects of the light beams are added together on the screen (or in the eye) as the white screen reflects indiscriminately all light which falls on it (and your eye likewise reacts to the sum of all the light coming to it from any given point in space).

It is a very different matter if we consider *dyes* or *pigments* however. These have the property of *absorbing* and as it were removing light radiations of some colours and of reflecting (or allowing to be transmitted) the remaining colours of the incident light.

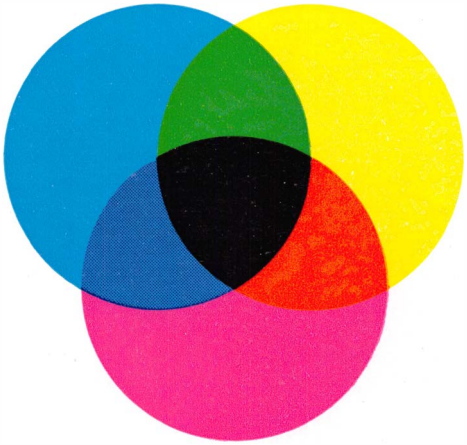
For example a yellow pigment (or dye) absorbs the blue and reflects the green and red (which combine to give an effect of yellow in our eye). Similarly a cyan (blue-green) pigment absorbs red and reflects the blue and the green. If we mix these two pigments – yellow and cyan, then the result will be that only green will be reflected since both the blue and the red will be absorbed by one or other of the pigments.

Now this is exactly the result produced when we mix ultramarine blue and yellow colours on a palette. To sum up we can say that when mixing coloured materials (not light beams), their absorption properties (or 'subtractive' properties) are added and control the behaviour of the mixture and the ability to reflect light of any colour is only preserved when it is *common* to all the pigments used in the mixture (otherwise, of course, one of the pigments would absorb that particular colour). The same results are obtained when we superimpose two or more transparent filters in the path of a beam of white light. In this case each of the filters *subtracts* from the white light in turn a part of the light making up the whole beam, the part which it absorbs.

A



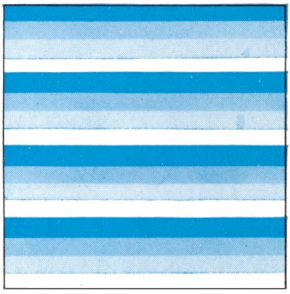
B

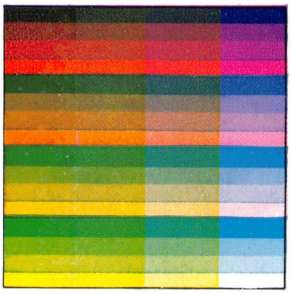






C





These properties are used in oil painting, watercolour, colour printing and colour photography which is done by 'subtractive' processes.

From what has been said it will be seen that in principle it is sufficient, if it is desired to know what result the mixture of two dyes will give (or their superimposition if they are to be observed by transmission), to know only which colours each of the separate dyes reflects (or transmits) and which each absorbs. The following combinations, for example, can be found. They can be checked by experiment, and play an important part in subtractive systems of colour photography.

A *magenta* dye (=red and blue) and a *cyan* dye (=blue and green) when combined give *blue*.

A *yellow* dye (=red and green) and a *cyan* dye (=blue and green) combine to give *green*.

A *yellow* dye (=red and green) and a *magenta* dye (=red and blue) combine to give *red*

The following characteristics will make it easy to remember the difference between *additive* and *subtractive* colour mixing:

1. *Additive combinations:* When two-coloured light beams are mixed the resulting

← *Fig. 102 Combination of colours.*

A. ADDITIVE COMBINATIONS

If beams of light from three projectors are mixed, each being one of the primaries (Maxwell's experiment), we have:

blue +green=cyan (blue-green)
blue +red =magenta
green+red =yellow

Spectroscopic determinations moreover show that yellow objects reflect green and red light (500–700mμ approx.), magenta (or purple) objects reflect blue and red light (400–500mμ and 600–700mμ approx.) and cyan bodies (blue-green) reflect blue and green light (400–600mμ approx.). These facts are also used in subtractive system.

B. SUBTRACTIVE COMBINATIONS

If we superimpose pairs of filters of colours complementary to the primary colours and view them by transmitted light we see that subtractive combinations give the following results:

cyan and magenta=blue cyan and yellow=green magenta and yellow=red

Superimposing the three filters we subtract (absorb) all three primaries, i.e. all the light and the result is black.

C. THREE-COLOUR PRINTING (SUBTRACTIVE) COMBINATIONS

By superimposing in varying proportions inks of the colours used for three-colour printing, yellow-magenta (purple) and blue-green (cyan) we can produce from these three colours the gamut of all other colours in a manner similar to that used for subtractive three-colour photography. Usually in printing we use an additional block in colour work – for black ink (the 'black printer') – which helps to improve the rendering of grey shades and to correct some of the imperfections of the coloured inks used.

beam is lighter, i.e. brighter than the lighter of the two beams of which it is composed. There is, therefore, *addition of light.*

2. *Subtractive combinations:* When coloured paints are mixed or coloured screens (filters) are superimposed the resulting colour is always darker than the lighter (or darker) of the two colours used. There is, therefore, a *subtraction* of light.

COLOUR SEPARATION

Having now decided that we want to represent all the colours of nature by appropriate mixtures of only three colours – how are we to choose, or shall we say select or separate out, the parts of the subject that are to be reproduced in each of the three colours?

The separation is simple: Place between the subject and the camera a filter of the appropriate colour.

Say, for example, we photograph the same subject on three pan plates in succession, each time with a different filter in front of the lens – first a blue, then a green, and then a red. After development we have three negatives. The first negative then has a complete record of all the parts of the subject which reflect or emit blue light, the second a record of the green in the subject, the third of the red. Although these negatives are themselves in black and grey silver at present.

If we now make transparencies from each of these three negatives it is easy to see that each point on the diapositive is transparent to transmitted light to exactly the same degree as the quantity of coloured light, according to the filter used, emitted by the subject itself at the corresponding point. For example a blue sky photographed through a blue filter will be dense on the negative and clear (transparent) in the lantern slide made from it. If we now place this transparency in a lantern illuminated by blue coloured light – using the taking filter – we can project on to a screen *all the blue light* in the original scene. Similarly for the two other colours.

★ One-shot camera

It is easy enough to make three successive negatives of the same subject if it is a still life or a studio arrangement but is practically impossible with living subjects. Special cameras have been built which are fitted with two internal partially reflecting mirrors A and B with which three negatives can be made simultaneously on plates 1, 2, and 3 (fig. 103).

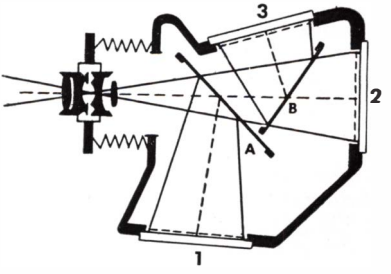


Fig. 103 Reckmeyer one-shot three-colour camera.

In front of each plate is fitted the respective colour filter, green, blue, and red. Part of the light from the lens traverses the two mirrors A and B to reach the rear plate, and part is reflected from both of the mirrors in turn to the other two plates. In this way we get three-colour separation

negatives. If after development we make diapositives from each negative and project each of these in register on a white screen each through the appropriate taking filter the subject will be reproduced in natural colours.

Colour reproduction by *additive* processes

Using three projectors of the same light output we project on a screen the three positives which we have described above, each one through the filter which was used to make the corresponding negative. If the three projected images are superimposed in register the subject is produced in three colours on the screen. This is not a very practical proposition (although triple lanterns were once made and used) and we naturally try to reduce the number of negatives and projectors to one. This has been done by a method which is both simple and elegant. Instead of using three separate filters respectively blue, green and red, we will use a *single* filter which is made up of a fine mosaic of very fine elements of these three colours uniformly distributed over the whole area and we will place this trichrome filter between the emulsion and the base (glass or film base).

The exposure then has to be made through the back of the plate or film base, the incident light rays will then pass through the little filters before reaching the emulsion.

If such a plate or film is then developed and reversed into a positive by normal black and white procedures it will then reproduce all the colours of the subject as photographed.

It is easy enough to explain the way the colours are reproduced by this process. Imagine, for example, a red object. At the time of exposure the corresponding part of the emulsion is only exposed behind each of the small red filter dots in the mosaic as the blue and green filter dots absorb red light. After reversal to a positive the emulsion will become transparent (clear) behind the red grains and opaque behind the green and blue points. As a result this area of the subject appears red on the plate or film just as it should. The same thing happens with the other colours – all the various hues and shades can be obtained by the 'masking', partial or complete, effected by the blackness of the developed and reversed emulsion behind each of the blue, green and red points. The proportions of the three colours are adjusted by the manufacturer so that the film or plate is neutral in colour when the emulsion is completely transparent.

The mosaic or coloured grid is practically invisible because of the small size of the dots, although it can easily be seen if examined under high magnification.

Another additive system which has been used for cinematography is to place a banded filter in front of the camera and the projection lens. This filter has three bands respectively, blue, green and red. The film is exposed through the base which is embossed with a network of minute lenses (Lenticles) which throw on to the emulsion layer tiny images of the filter. (A black and white emulsion thus records behind each lenticle a series of three colour separations). The film itself remains uncoloured. On projection the coloured result is synthesized in exactly the reverse way to the analysis. Additive systems were

responsible for the first workable processes of colour photography, but in practice the preference is given almost completely to subtractive systems which can be called without exaggeration the 'modern method'.

Reproduction of colours by *subtractive* processes

★ Principles

Let us return to our three positives made from the three negatives made through the blue, green and red, and let us *tone* these positives respectively *yellow*, *magenta* and *cyan* (blue-green), these being the complementary colours to the taking filters. Now superimpose these three positives in register with each other. When viewed by transmitted light or projected on to a screen (with a single projector) these three positives combined will reproduce all the colours of the subject.

This may seem strange at first sight, but is quite true and sensible. Consider, for example, the diapositive toned yellow which is made from the blue filter negative. The darker parts of the positive image correspond to areas in the subject where there was very little blue, and these are now yellow (since the positive slide has been *toned* and not painted). These dark yellow areas absorb *blue* light and let all the green and red light (green light and red light=yellow light) pass freely. On the other hand the clear parts of the positive which correspond to areas of the subject which are rich in blue lets all the light through (including all the blue) quite freely. Summing up, we can say that blue light is allowed through this yellow toned positive in exactly the same proportions as it exists in the subject itself, and in addition all the red and green light passes freely through the whole area of this positive. This light must now pass through each of the other two-toned positives in succession. Let us see how it is affected there.

Areas that are pure blue in the subject do not reflect or emit any green or red light and are consequently dark on these two positives made from the green and the red filter negatives respectively, and which are toned magenta and cyan (blue-green). White light which has traversed the clear areas of the yellow-toned positive must then pass successively through the magenta (red and blue) which subtracts green light and then through the cyan (blue and green) which subtracts the red light, leaving only the blue unchanged. A blue object therefore appears blue. The formation of all the other colours whether they are simple primaries or complex mixtures of all three can be explained in a similar manner.

The starting point for all subtractive systems is white light from which the three positives made from the blue, green and red colour separation negatives and which are toned respectively yellow, magenta and cyan, subtract each in turn the primary colours which are not present in the subject.

★ Tri-colour printing

Methods similar to the above have been used for a long time in letterpress printing. Three 'separation' negatives are first made through blue, green and

red filters respectively. These are then used to make the printing blocks which are inked with yellow, magenta and cyan inks and printed one after the other on the same sheet of paper with the images correctly in register. Magnificent reproductions in full colour can be made in this way. A fourth block, inked with black, is often used to improve the neutrality of the greys and the depths of the full blacks because it is not possible yet to make three colour inks which possess exactly the characteristics as required by trichromatic theory.

This is the method that has been used for the reproductions of 'Gevacolor' photographs which have been inserted in this chapter.

It is undoubtedly well worth saying here that with all these methods in which three separate images are obtained and have subsequently to be super-imposed (yellow, magenta and cyan, possibly also black) considerable care and some considerable experience are essential not only to register the three or four images, one on top of each other, accurately, to minute fractions of an inch, but also to ensure that each of these images has exactly the necessary contrast and brightness. It is usually necessary to adopt precise sensitometric methods of control if perfect results are to be obtained. Although the theory of these methods is relatively straightforward they need considerable experience to apply them satisfactorily in practice.

★ The 'Integral Tripack' film

Modern colour photography by the subtractive system has been simplified to a great extent by the perfecting of methods by which the three monochrome positives we have discussed above can be produced simultaneously and automatically superimposed in register on each other, on one and the same piece of film. This has been done by coating on the film base three emulsion layers, each one of which is sensitive to one of the primary colours. After processing to a positive each of these is then coloured *in situ* with dye of the complementary colour to its primary sensitivity so that the process we have described above has been carried out without separating the three images physically from each other. Such films are called integral tripack films.

Such a system had been proposed and investigated in a remarkable piece of work by Fischer before 1911, but it was only after many years that it was possible to put it to practical use in our modern methods of colour photography, because of the considerable manufacturing and technical difficulties which had to be surmounted.

To form the colours in three superimposed thin sensitive layers on the same film base numerous methods have been tried; among them:

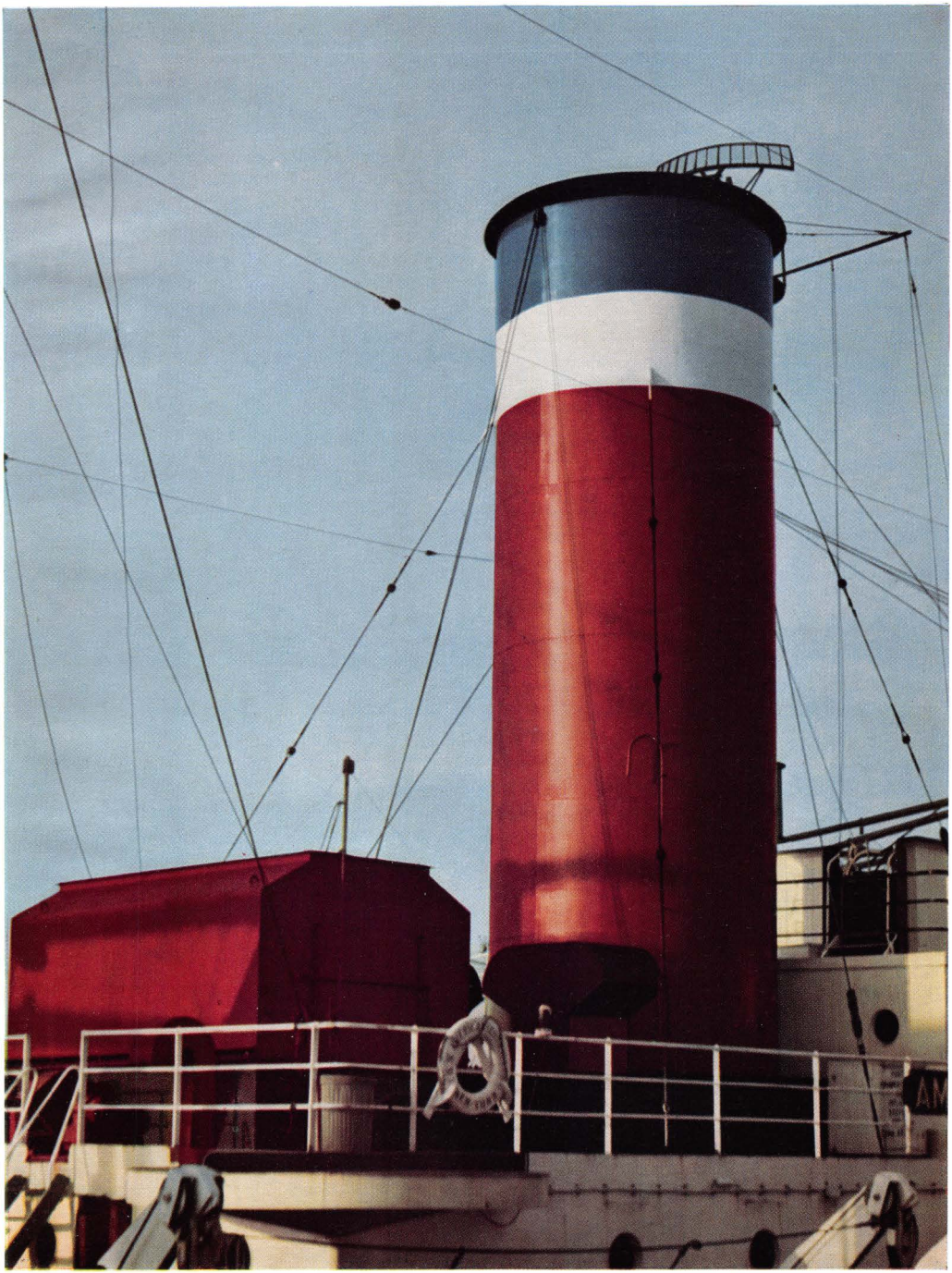
- toning of the silver image;
- selective hardening of the image;
- formation of azo dyes;
- selective destruction of dye materials;
- formation during development of dyes (chromogenic development).

It is *chromogenic* development (colour-coupling dye formation) which has proved the most successful for many reasons, chief among which is the high sensitivity which can be realized. This method can be further divided into two main classes:

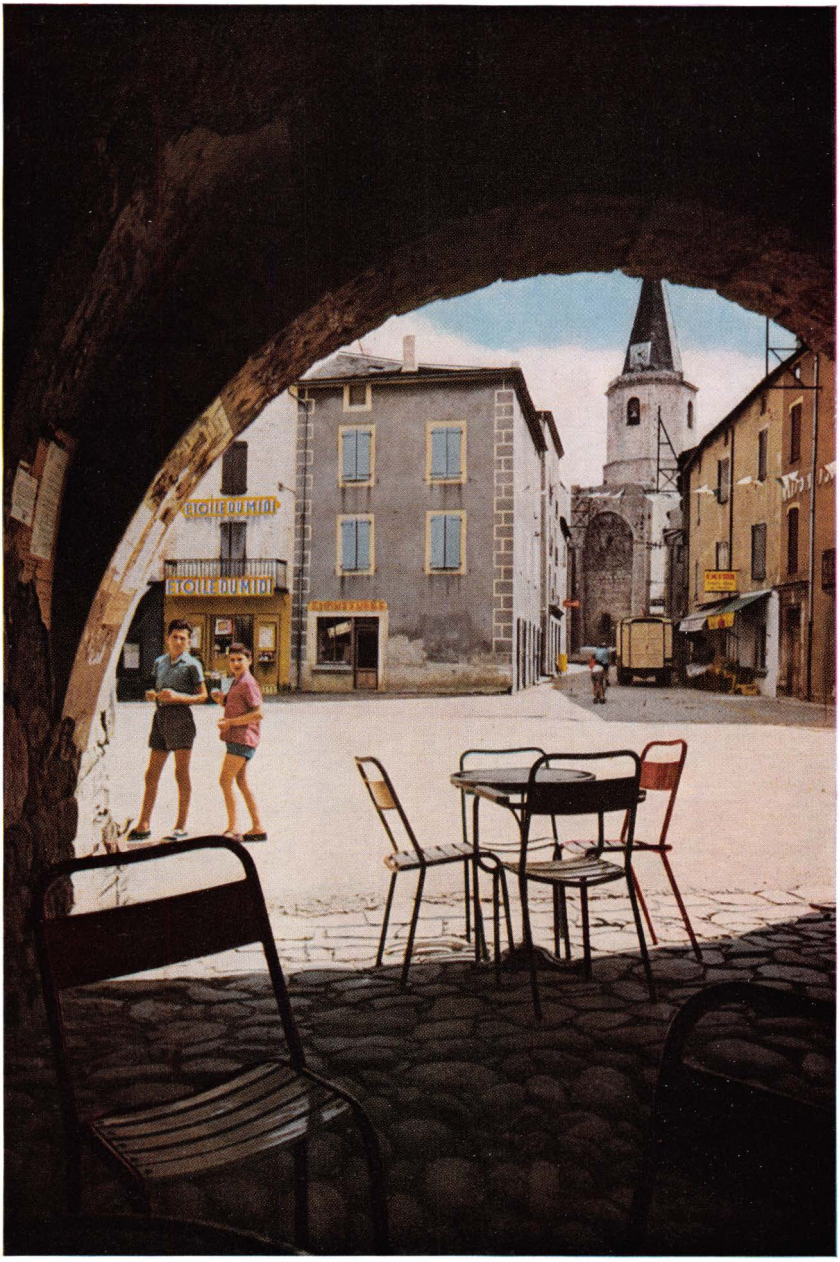
(*a*) In one method the colour formers are *in the processing solutions*.

(*b*) In the other method the colour formers are incorporated in *the film* at the time of manufacture (hence the term 'substantive' couplers).

Gevaert have adopted the second method in which the colour couplers are incorporated in the film during its manufacture.



Gevacolor Negative
Photo Asad Ali



Gevacolor Reversal
Photo Willy Ronis

TAKING PICTURES WITH 'GEVACOLOR'*

PROCESSES

There is a negative-positive and a reversal system available in colour photography just as there is for black and white work.

'Gevacolor Negative' films can be used to make colour negatives that can be printed or enlarged on the 'Gevacolor' paper or 'Gevacolor Copyfilm' to give as many copies as may be required.

To those who have never seen them before these negatives look most peculiar. They are not only negatives in the sense of light and shade, as in black and white photography, but also in respect of their colours. These are complementary to the natural colours of the subject. Red areas are shown as cyan (blue-green), blues as yellow, and so on. These colours are changed back again when they are printed on to positive material and then reappear in the correct natural colours.

'Gevacolor' negatives can also be printed or enlarged in black and white on the usual Gevaert papers in the normal way ('Ridax', 'Gevabrom', etc.). This gives it one important advantage. If, for example, a particularly good opportunity occurs to take a photograph but the lighting is not satisfactory for colour photography the photographer is not prevented from carrying on and taking his pictures just the same and he can print his pictures in black and white. Thus 'Gevacolor Negative' can be used on all occasions.

'Gevacolor Reversal' films are meant, on the other hand, to give direct positive colour transparencies suitable chiefly for projection. Gevaert do not make duplicates or prints from these films. To distinguish these two types of films easily the name is followed by the letter N for 'Gevacolor Negative' and by the letter R for 'Gevacolor Reversal' films respectively.

TYPES OF FILMS

'Gevacolor' films are made in two types suitable for particular lighting conditions:

One type for *daylight* and a second type for *artificial light.*

Why have two kinds of film?

Light varies in colour

Everyone knows from experience how the colour of a piece of cloth changes its appearance according to whether it is examined in daylight or artificial light.

* By J. Lauwers.

These variations arise from differences in the composition of the light illuminating the subject.

However, our eyes possess considerable powers of adaptation which tend to offset these differences: for example, if, during the daytime we enter a room lit by electric light, the lighting seems yellowish at first, but the yellow effect disappears as soon as the eyes have had time to accustom themselves to it. This ability to adapt – coupled with the ease with which we forget past lighting conditions – partly conceals the extent to which light loosely called 'white' can vary in colour according to the time of day, the season and the weather conditions.

A colour film, on the other hand, tends to register colours as they really are without allowing for changes of hue caused by different light sources, as our eyes do.

It follows that variations in the colour of the lighting have a considerable influence on the results obtained in colour photography. It is essential to take these variations into account when making the exposure and to use some means of offsetting them where appropriate.

This applies particularly to 'Gevacolor Reversal' films as they cannot be corrected at subsequent stages of the process.

Colour temperature

To explain these changes and to help us to counteract them, light needs to be analysed. It is, we know, made up of light of various colours. If a coal fire is examined it will be seen that the fuel is dark red when burning slowly but becomes bright red, then yellow, then still whiter as the temperature rises. If the temperature could be raised even further the glowing coal would turn from white to blue in colour.

A hot body therefore takes on a particular colour according to its temperature. As the temperature rises, the amount of blue in the light emitted increases as compared with the amount of red. The relative amount of green light is generally somewhere between the blue and the red.

These facts have made it possible to grade light sources according to their 'colour temperature', that is to say, the temperature of a so-called 'black' body emitting light of the same spectral composition. This temperature is expressed in degrees of absolute temperature or degrees Kelvin (obtained by adding 273° to the temperature expressed in degrees Centigrade).

The colour temperature therefore forms a fairly accurate measure of the *quality* of the light – that is of the relative amounts of blue-green and red light which go to make up its overall 'colour' – and replaces general descriptions such as 'yellowish', 'bluish', etc., by more precise specifications. This makes it easy to compare different light sources as far as their visual effect is concerned. It also gives us some idea of their photographic effect. This indication is, however, only approximate, as light sources are often made up of discontinuous collections of light of different colours (wavelengths) not corresponding at all

closely to 'black-body' radiation, and in addition light of these wavelengths may have a much stronger or much weaker effect on a photographic emulsion than on our eyes. Fluorescent tubes are a particular case in point, and their use is not advised unless special effects are desired.

As far as incandescent lamps are concerned the colour temperature varies considerably with the voltage of the supply. An increase or decrease of 20 volts in a 220-volt supply causes a corresponding variation of about 100° in the colour temperature. It is advisable to check the mains voltage from time to time, making the test with the lamps burning and at a place on the supply-line as near as possible to the lamp sockets. After a certain amount of use over-run photoflood lamps have a tendency to burn yellow, and this causes a reduction in their colour temperature.

N.B. The colour temperature gives no indication of the *intensity* of the light. This is measured, as in black and white photography, by means of a photo-electric exposure meter.

★ Colour temperature of some available light sources when operated at their correct voltage

Ordinary ½ watt bulb	2,800°K
Type B Photographic Lamp (100 hours) C. J. Series, etc.	3,200°K
Projector Lamps	3,200°K
Type A Photofloods (Nos. 1, 2 and 4)	3,400°K
Ordinary low pressure carbon arc	4,100°K
Daylight within two hours of sunrise or sunset	4,500°K–5,000°K
Clear flashbulbs	4,000°K
White flame arc	5,000°K–5,500°K
Mean Noon sunlight	5,500°K
High Intensity arc	5,800°K–6,000°K
Electronic flash	6,000°K–6,500°K
Sun-blue sky	6,000°K
Overcast sky	8,000°K
Shadow areas, lit from blue sky only	10,000°K–12,000°K

As will be seen from the table above the colour temperature of the light falling on the subject can vary from 2,800°K. to 12,000°K. and these values are by no means the outside limits.

It would be ideal from the colour point of view if we had a film balanced for each source of a different colour temperature. Obviously this is quite impracticable. How many films ought we to have?

The practical solution which has been adopted is to use filters to bring the colour temperature of the light back to the colour temperature for which the film has been balanced during manufacture. This being so, theoretically only one type of film would then be necessary. However, if we did this we should find that for the extreme cases we should have to use a correction filter which had a factor of about 8 times, and this would be quite impracticable.

The way to get over this is to use two films, balanced for use in average illumination of the two most usual types of working conditions – daylight and artificial (studio) lighting.

One is accordingly balanced for exposure in full sunlight with a clear sky and with it we can photograph under normal conditions outdoors or in any conditions where the lighting is roughly the same colour temperature – i.e., it can also be used with blue flashbulbs and with electronic flash.

The other is balanced for light of a colour temperature of 3,200°K. This choice is governed by the fact that most professional studios, including film studios, use 100 hour Type B lamps or C.T. lamps of this colour temperature. These give adequate brightnesses and a longer life than the photoflood lamps of 3,400°K. which only last 2, 6 or 10 hours, depending on their wattage.

To avoid any confusion the packages in which 'Gevacolor' film is supplied are printed with the following distinctive symbols:





Fig. 104 Symbols on 'Gevacolor' packings.
(a) For daylight. *(b) For artificial light.*

The name of the film is followed by a number:
5 for daylight films;
3 for artificial light films.

MAKING COLOUR EXPOSURES

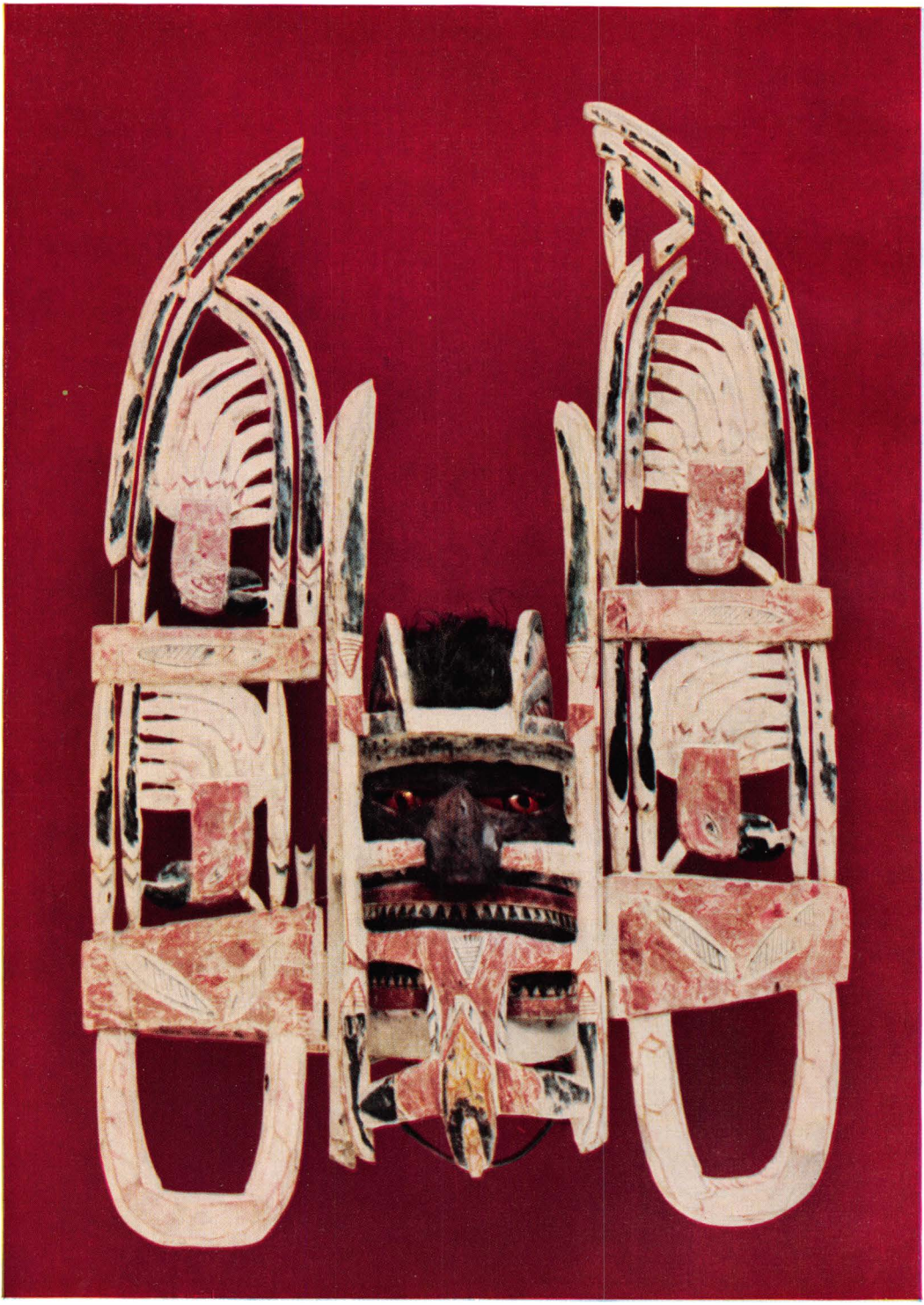
Colour contrast

There is one essential difference between colour and black and white photography. Colour photography has to show the colours much as they are in reality, black and white merely interprets them. All the colours are changed into tones of grey that are darker or lighter according to the sensitivity of the film and as a consequence it is possible for several different colours to be an absolutely identical grey in a photograph made on panchromatic film. Some violets cannot therefore be distinguished from greens or oranges provided they are lit evenly, whereas in colour these three colours differ from each other considerably.

Clearly then colour contrast has an important role in colour photography and the different parts of a picture will stand out from one another because of the play of colours, provided the illumination is more or less uniform. In black and white on the contrary, the different parts of the picture are solely differentiated from each other by the brightness contrasts.



Gevacolor Reversal - Photo Arthur Anthonis *Brussels by night*



Gevacolor Negative
Photo H. Melis

Kepong Mask,
Melanesia, New Ireland

Skilful handling of these two types of contrast and the balance between them, it is easy to appreciate, offer great possibilities to the photographer who really wants to make use of them to best advantage.

The colour of the light

As we have seen already the results obtained are very much influenced by the colour temperature of the light used.

This can be measured with instruments that are simple enough to use – most of them are rather similar to a photo-electric exposure meter, some colour temperature meters can be used as exposure meters or photometers as well. Although they can be very useful in many cases, particularly in artificial light, they are, however, by no means essential.

It is advisable to work with lighting corresponding as far as possible to the type of film in use, otherwise the results will display a lack of colour balance. Exposures that are made in light of too high a colour temperature will have an overall bluish cast; those made with light of too low a colour temperature will be orange. Thus sunlit scenes taken on artificial light film will have a strong blue cast. This lack of colour balance will become more marked, the more the colour of the light used differs from that in which the film is intended to be used.

★ Note

'Gevacolor Negative N5' film has considerably more 'colour latitude' than the Reversal film because the necessary corrections can be made when the negative is printed on to 'Gevacolor' paper. This film can be used as it is for taking pictures in daylight with blue flashbulbs, *clear* flashbulbs and electronic flash. If you want to use photofloods, type B or ordinary filament lamps then it is best to use a 'Gevacolor' CTB-8 filter (see below).

Generally speaking our eyes will accept pictures which are 'warmer' or more yellowish in tone than normal, but will only tolerate a much smaller deviation towards 'cold' (bluish) tones.

Small deviations of colour temperature below the correct level are therefore not unduly detrimental and can still give acceptable results. In certain cases such deviations may even be desirable if they serve to enhance the 'atmosphere' of a certain scene. No one for example will be surprised if a photograph taken at sunset displays an overall orange tint; it is a perfectly natural effect. In the majority of cases this light will only give good results with landscapes.

It should be noted that the example given is only one of many possible instances, and no rigid rules can be laid down. The important point is to decide whether what one might call a 'normal' colour rendering is desired (in which the greys are absolutely neutral) or whether the 'atmosphere' of the colours of the original is to be faithfully reproduced in the photograph. Only in the former case should the 'rules' be adhered to and the prescribed corrections applied.

On the other hand when special effects are desired the first requirement is sound judgment of colour, and this can only be acquired by long experience.

When working with incandescent lamps a variation of 50°K. above or below the required colour temperature may usually be tolerated without the need for any correction.

Greater variations must, however, be offset by special *correction filters*. It is well to remember that in spite of this correction, even in the best conditions the colour rendering *will seldom be as faithful* as in normal lighting conditions. It must also be borne in mind that a filter alters the colour rendering of the entire scene. It follows that no satisfactory overall correction of a subject lying partly in the shade and partly in direct sunlight is possible, since we have seen from the table above that the shadows are generally much bluer than the directly lit parts of the subject.

Ordinary filters for black and white photography are quite unsuitable for use with colour films.

★ Filter factors

Filter number	*Filter factor*	*Open lens aperture* by*
CTO- 1	1·1	—
2	1·15	—
4	1·2	1/4
8	1·3	1/3
12	1·4	1/2
16	1·6	2/3
20	1·7	3/4
CTB- 1	1·25	1/3
2	1·4	1/2
4	2	1
8	3	1 2/3
12	5	2 1/3
16	8	3

* Lens aperture to be opened up by the amount shown in fractions of a stop.

★ 'Gevacolor CT' filters

Gevaert supply special correction filters under the name of 'Gevacolor CT' filters.

These filters are made as gelatine sheets and can be obtained cemented between optical glasses on request.

★ Table for using 'Gevacolor CT filters

Lighting	*Colour temp. approx. °K*	*Type of film*		
		R5	*N5*	*N3*
Ordinary ½-watt filament lamps	2,800°	CTB-4	CTB-2	CTB-12
Type B (100 hr.) photographic lamps, projection lamps, C.T. lamps, spotlights	3,200°	—	—	CTB-8
Photofloods (Nos. 1, 2 & 4).	3,400°	CTO-2	—	CTB-8
Clear flash bulbs	3,800° to 4,000°	CTO-4	CTO-2	—
Blue-coated photofloods (daylight lamps)	5,000°	CTO-8	CTO-4	—
Sunlight within or two hours after sunrise and before sunset	5,000°	CTO-8	CTO-4	—
Sunlight, blue sky ..	5,900°	CTO-12	CTO-8	—
Blue-coated flash bulbs. H.I. arcs	6,000°	CTO-12	CTO-8	—
In the shade: within 1 or 2 hours of sunrise or sunset ..	6,000°	CTO-12	CTO-8	—
Electronic flashlamps (Xenon)	6,000° to 6,500°	CTO-12	CTO-8	—
Daylight: cloudy sky or misty	8,000°	CTO-16	CTO-12	—
In the shade: clear blue sky	10,000° to 12,000	CTO-20	CTO-16	CTO-4

They are placed, like other filters, in front of the camera lens.
The filters are available in two sets, orange and blue.
The orange series, comprising 7 CTO filters, is for use when the colour tem-

perature of the light is too high; the blue series, comprising 6 CTB filters, when the colour temperature is too low.

They are numbered as follows, in order of increasing density:

CTO-1, CTO-2, CTO-4, CTO-8, CTO-12, CTO-16, CTO-20.

CTB-1, CTB-2, CTB-4, CTB-8, CTB-12, CTB-16.

Where necessary two CTO or two CTB filters may be used together. To ascertain their combined effect add together the filter numbers. Thus, if a CTO-1 and a CTO-2 filter are used in conjunction, the sum of the numbers (3) indicates that the combined effect is between that of the CTO-2 and the CTO-4 filter.

★ 'Gevacolor UV' filter

Besides 'Gevacolor CT' filters, which are used to compensate for variations in colour temperature, special filters designed to absorb the excess ultra-violet rays are also used in colour photography. They are required for distant views when a slight mist covers the subject, especially at the seaside and in the mountains, and in aerial photography.

Such a filter is sold under the name of 'Gevacolor UV Special'.

Like the 'Gevacolor CT' series it is made and supplied in gelatine sheets but may be obtained cemented between optical glasses on request.

Subject contrast

Another matter of considerable importance in colour photography is the subject brightness range – the ratio between the brightest and darkest parts of the subject – called for short the subject contrast.

Many conflicting statements have been made about this and we, therefore, consider it wise to go into it in some detail.

Three separate and distinct quantities are involved here, they are respectively:

(i) – the difference in reflecting power of different parts of the subject (reflectance ratio).

(ii) – the difference in the brightness of the light illuminating different parts of the subject (lighting ratio).

and the third, which is the product of (i) and (ii) is:

(iii) – the difference between the brightnesses of different parts of the subject (as they appear to the camera) (the subject contrast – or subject brightness range).

Reflectance ratio × Lighting ratio = Subject brightness range.

★ What is reflectance?

The reflecting power (or reflectance) of a uniformly coloured opaque diffusing surface is *the ratio between the quantity of light reflected by the surface and the quantity*



Gevacolor Reversal
Photo J. Dworkine



Gevacolor Reversal
Photo W. Schmölcke

incident on it. The reflectance is hence a property of the surface and cannot be changed.

If we take any subject lit uniformly from the front we can say that it is made up of different areas, each of which reflects a different amount of the incident light, i.e. each area has a reflecting power peculiar to itself. If, for example, the darkest area only reflects 1/10th of the light that the lightest area does then the ratio of the reflectance is 1 : 10. You should note that the terms darkest and lightest do *not* necessarily mean 'black' and 'white'. In the same way colours reflect some part of the light. The reflectance ratio of coloured surfaces can thus be measured – yellows and blues for instance.

When the surface is uniformly lit all over by the source as in the case considered above the subject brightness range (or subject contrast) will be the same as the reflectance ratio, since the lighting ratio is unity: the lighting intensity being a single fixed value over the whole project.

★ Lighting ratio

The second factor to be considered is the intensity of the light on any surface area. This is found by dividing the luminous flux incident on it by the area of

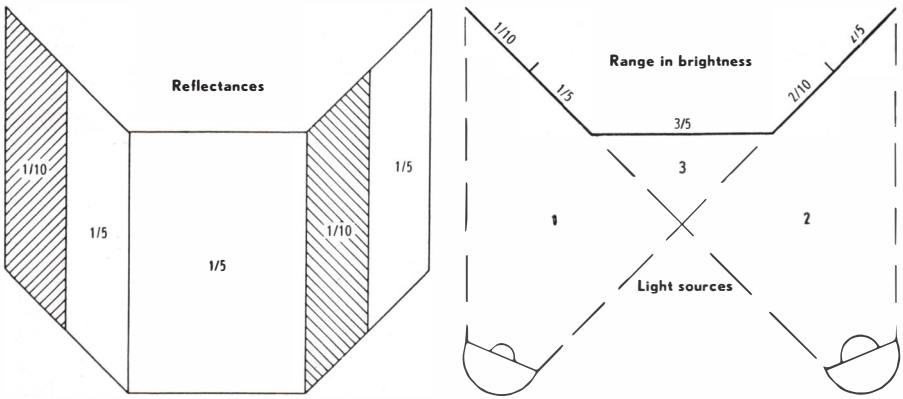


Fig. 105 Reflectances – Lighting – Brightness ratio.

the surface and is expressed in ft.-candles (1 lumen per sq. ft.). (In the metric system it is given in lux (1 lumen per sq. m.) 1 ft.-candle is approximately equal to 10 lux.) British and American *photometers* are usually calibrated in ft.-candles, whereas exposure meters are usually calibrated in brightness units, such as candles/sq. ft. or candles/sq. m. The difference is not important for our purpose here.

Unlike the reflectance, the lighting intensity on different parts of the subject can generally be altered at will – by moving the light sources closer or further away from the subject and by altering the relative power and size. To determine the lighting ratio, or ratio of intensity, we should not compare the intensity produced by the most powerful source with the intensity of the weakest, but compare the intensity produced by all the sources together with the intensity of the weakest one.

Let us examine a subject in relief which is basically composed of three plane surfaces, the outer turned backwards, as shown in fig. 105. The two side planes are divided into areas which have reflecting powers (reflectances) of 1/5th and 1/10th respectively. The front centre plane has a reflectance of 1/5th. This subject is then lit with two lamps, one of which gives twice the light output of the other and placed (see right-hand diagram of fig. 105) so that one lamp lights the left side and the front plane only, the other the right side and the front side only. The front plane is thus lit by both sources and each of the side planes by one of the lights only. (The lowest intensity falls on the left hand plane = 1, the highest on the centre plane = 1 + 2 = 3 which is lit by both lamps together. The ratio of intensities or lighting contrast is therefore 3 : 1 and not 2 : 1.)

★ Subject brightness range

From these two ratios above we can calculate the subject brightness range (or subject contrast). As we have already said, this is the product of the other two considered for each area independently. In the example we have given, therefore, we have the darkest area = 1/10th × 1 = 1/10th, and the brightest area = 1/5th × 2 = 4/10th. The total subject contrast is therefore 4 : 1.

Now we can see that our first proposition was correct since:

Reflectance ratio is 2 : 1.

Lighting ratio is 2 : 1,

and the lighting contrast as we have found is 2 : 1 × 2 : 1 = 4 : 1.

★ Can these ratios be measured?

The subject brightness range or subject contrast can be measured quite adequately with exposure meters that measure reflected light as are used normally for photography. It should, however, be realized that when we use such an instrument the contrasts as measured are about four times smaller than they in fact really are because of unwanted reflections (and the relatively wide angle of acceptance of the photocell system which is essential if the average reflected light working method is used). The true brightness range can only be measured with special high precision apparatus, although there is one instrument – the S.E.I. Photometer available in Britain and America – which can be used for such determinations, although it is calibrated as an exposure meter (or photometer). As very few photographers will have an instrument of this type the values given here are based on the use of the ordinary exposure meter. The

lighting ratio cannot, however, be measured directly by these exposure meters. This latter ratio must be measured with a photometer (ft.-candle or lux-meter) or an 'incident light' exposure meter which is provided or fitted with a diffuse collector. Many types of exposure meter now have an attachable diffusing cone, disc, or rectangle, such as the Weston Invercone, for this purpose, see the makers' instructions for their use. An ordinary reflected light meter can be used satisfactorily with a white or neutral grey card reflector, provided the card is held in the light to be measured and not shaded by the body or hand. The meter should read only the reflected light from the card.

Exposure meters measuring incident light have been in use for quite a while now in film production studios where this method of measurement has the greatest advantages. This method is, however, now used more and more in ordinary photography, especially for colour portraiture. While it is extremely difficult to measure the lighting contrast of some outdoor scene or subject, it is easy enough to do so in the studio where the light sources are completely under the photographer's control and can be arranged to suit his choice.

★ Importance of contrast in colour photography

Colour film can only record and reproduce faithfully a somewhat restricted brightness range. The subject contrast must, therefore, be kept within rather narrow limits.

As we have stated above the reflectance of a subject is fixed and we cannot usually change it. On the other hand we can do what we like with the lighting contrast. This is all we can alter to achieve the result required. In practice the reflectances ratio never exceeds 40 : 1 for the most extreme case. For instance, the ratio of the reflectances of two matt paper surfaces, one black, the other white, and lit uniformly, is only about 15 : 1. It is reasonable to assume, since this is not by any means a special example, that the reflectance ratios met with in everyday practice will be generally somewhat less than this. In all these considerations we are *leaving out* the specular highlights, reflections from eyes, water, etc., which are far too bright, and which need to register as clear white anyway, and the deepest 'trapped' shadows where practically no light falls and in which we wish to see no detail at all – merely rendering them as the fullest black possible. Our interest is centred on the lightest ordinary white and the darkest tone in which detail is required. But, of course, if the lighting ratio is able to attain high values so will the subject contrast range (e.g. in 'against-the-light' shots in bright sunlight).

Is there then a limit which should not be exceeded if distortions of colour rendering are to be avoided? It is difficult to give hard and fast figures and to keep the photographer to an absolutely rigid technical rule. Everything depends on what part of the picture is important as far as accurate colour is concerned. In exterior scenes for instance without any important foreground the details in the deepest shadow are unimportant. In most of these anyway, particularly distant scenes, the contrast is considerably reduced by atmospheric haze and by

camera and lens flare. It is mainly portraits and other close-up subjects that need careful watching from the point of view of the subject brightness range.

As a *general rule* good results will be achieved if the lighting ratio used for reversal films is not allowed to exceed 3 : 1. The reflectance ratios are usually fairly low in most cases, and the *result is to be examined by transmission*.

Negative colour films, however cannot be allowed to exceed a limit of 20 : 1 for the overall subject contrast which means that for a subject like two pieces of matt paper as described above (which in fact represent all subjects) the lighting ratio cannot exceed about 1 to 1·25 : 1. This is because the final result is a *paper print* and the range of colour contrasts which can be faithfully shown on 'Gevacolor' paper is only about 20 : 1 or with small departures perhaps 30 : 1. If, however, the reflectance ratio were to fall to 5 : 1 instead of 15 : 1 then the lighting contrast could be raised to 4 : 1.

We repeat, however, that a definite limit cannot be given. In certain circumstances the values given can be exceeded, at other times all the ratios must be kept to the minimum. For diapositives, however, intended *solely* for projection, greater liberties can be taken than those intended for prints or reproductions on paper. With negative films especially it is best to keep the subject contrast to a low level because the paper on to which it will be printed cannot handle excessive contrasts and is to be viewed by reflected light.

Remember also that the exposure latitude decreases as the subject contrast increases. At the limit the exposure must be *absolutely* correct.

Practical applications

We now give the practical implications of the theory we have just gone over, especially as it concerns the colour temperature and the contrasts.

★ Outdoors

(a) In direct sunlight

When the subject is lit from straight in front by bright sunlight it is evenly illuminated and taking the picture presents no difficulties from the point of view of subject contrast. Most subjects fall well within the limits which colour photography can manage, moreover, sunlight between two hours after sunrise until two hours before sunset, in conjunction with a blue sky, has the colour temperature required for a daylight film balanced for about 5,900°K. A photograph correctly exposed under these conditions will give entire satisfaction. However, we need not be quite so rigorous for, if we do take pictures under these conditions, they may often lack depth and roundness so, although it is a good idea to start off like this, there is nothing against gradually trying out more 'plastic' lighting. When we say in 'direct sunlight', i.e. with the sun shining from directly in front of the subject, this is not an absolutely rigid rule from which no deviation whatsoever is permissible. With the sun slightly to one side, light shadows will

appear and the subject will acquire improved depth and life. It would be no exaggeration to say that this will be so in the majority of cases. An angle of 45° can, in general, be considered the maximum deviation allowed.

The same applies to the colour temperature which varies to a reasonable extent in the course of the day. But between the hours given above, and in the summer months, the variations are not detrimental because of the considerable power our eyes have of adapting themselves to slight variations in colour, especially the colour of daylight.

If the air is slightly misty with the sun only lightly veiled and still quite visible, with soft weak shadows, the light is very suitable for close-up portraiture. The colour temperature is in fact practically the same as that of direct sunlight, but the great lighting contrast is reduced satisfactorily to manageable proportions while the subject will not be made uncomfortable by strong sunlight. At the same time the deep shadows will not be so blue because the light haze will diffuse the white sunlight over the whole scene, shadows included.

(*b*) *Under other conditions*

What is to be done when conditions are not normal?

Let us consider first when only the colour of the light (its colour temperature) exceeds our 'normal' limits. Then afterwards we will deal with more difficult cases in which several things are varying at the same time. First: *In the shadows:* If there is no direct sunlight the subject brightness range is very much reduced. The lighting will thus be quite uniform being provided entirely by diffuse light. Subject contrast is, therefore, no problem. The difficulty here lies in the considerable departure in the colour of the light. Since the subject is lit by diffuse light from the sky only the illumination will have an overall blue cast which will be more pronounced the clearer the atmosphere. We want to call attention here to the fact that these conditions do not apply *only* to subjects in the shade, lit by large expanses of blue sky, which are designated 'open shadow' in the technical manuals; since the subject may, for example, be in a wood where the light is filtered through thick green foliage. It is obvious that in such a case the lighting will hardly be influenced by the blue of the sky at all and will have a green cast. We can give a definite recommendation not only for the case of 'open-shadows' but also for *all* cases where the entire scene is in shadow – the change in colour temperature can in such cases be compensated for by using a 'Gevacclor CTO 8' filter. In other cases it will be necessary to take into account the colour of objects which reflect light or which envelop or surround the subject because their colour will have a considerable influence. Experience is the only guide that can help to solve any particular problem. Overall colour conditions which are quite outside all that you have been accustomed to are not necessarily impossible. Everything depends on the result which you want to secure.

Next case: *Overcast sky or very misty:* If the sky is completely clouded over but the air is clear the lighting is very similar to that just discussed, with the sole difference that the blue coloration is reduced by clouds which spread diffuse sunlight over the whole scene. In this case also then we are faced with a change

in only the colour temperature of the illumination and this we can compensate for by using a 'Gevacolor CTO-4' filter.

N.B. When using 'Gevacolor N5' film it is *not* necessary to use these CT correcting filters, as these weak colour casts can be corrected when the negatives are printed on 'Gevacolor' paper. Except in cases where you want to record the 'atmospheric effects' it is not advisable to photograph in these conditions. The colours are dull and the intensity of the light is often rather low. The two cases considered above should be considered rather as exceptional and although it is easy enough to compensate for them there is nothing attractive about them.

Now only the third type of lighting is left to consider: *Side lighting or back lighting:* It is true enough to say that this is the true 'photogenic' lighting, but attractive as it may be it also requires the most careful attention and control.

The first effect of against-the-light colour photography whether partial or total is a great increase in the subject brightness range, such that this completely exceeds the range which colour film can record. On top of this there is a considerable departure from the ideal in the colour temperature of the shadow illumination. The prevalent remedy for this situation, to overcome both these difficulties in one go, is to use blue flashlamps or electronic flash having the same colour temperature, 6,000°K. The biggest difficulty is to get a satisfactory balance between the sunlight and the flash light. If the shadows are lit too strongly then the natural effect is completely destroyed. Take great care not to do this when you are making a close-up portrait with the flash mounted on the camera.

Another way of lightening the shadows is to use a white reflector or to make use of light-coloured objects (as white as possible) which are near the subject.

In addition to white walls the sand on the beach or dunes has a high reflecting power. Remember too that it is not absolutely essential to lighten the shadows. If is often better to expose only for the light tones and to let the shadows go.

These are all purely matters of taste and once more go to show that there are really no 'basic rules', and that the more experience you have the better you will understand and appreciate the delicate variations and deviations possible in colour photographs, even when made contrary to the rules. All you need the normal conditions for is to have a firm point of departure, to which you can return positively at will. Then you are free to experiment.

★ In artificial light

(*a*) *Studio lighting*

Provided you control the voltage of the electricity supply and run the lamps at the voltage for which they were made, and do not use old lamps you will have no difficulties with colour temperature if you use Type B lamps (100 hr. type-Argaphoto, etc.) specially made for studio use, giving light of 3,200°K., together with *film for artificial light.*

You can use photoflood lamps (No. 1, 2 or 4) which have a much shorter life,

and give light with a colour temperature of 3,400°K. (Photoflood, Photolita, etc.) with the same type of film provided you use a light orange 'Gevacolor CTO-2' correcting filter.

Ordinary half watt tungsten lamps, not over-run, should not be used.

If you do not have 3,200°K. studio lighting then clear flash bulbs can be used, but, as their colour temperature is about 4,000°K., you must use a 'Gevacolor CTO-4' filter.

The essential thing is not to use lamps giving light of different colour temperatures at the same time. In addition it is especially necessary to see that the scene is lit adequately. You need to pay particular attention to this point when large-scale subjects are being photographed, and it is best to provide additional lighting for the background and distance.

As has already been pointed out, it is easier to control lighting contrasts, and hence over-all subject brightness range, in the studio than it is outdoors. The lamps can fairly readily be moved around and arranged in the most favourable positions. Above all, do not attempt to vary their intensity by reducing or increasing the voltage by means of resistances or variable transformers, because this will cause serious alterations in the colour of the light, and be *careful* that reflectors, spotlight lenses, and diffusing screens and reflectors are neutral in colour and do not change the colour of the light.

You will be wise to remember that the finest details will be shown on close-up portraits and women sitters should be made up perfectly and men sitters be well shaved.

(b) Flash lamps

Although overrun lamps are normal for studios, most amateurs do not have them available and generally only use *daylight colour films*. They sometimes want to do some indoor work; for example, for a family party. Then they can use blue flash bulbs of about 6,000°K. or an electronic flash of about the same colour. If the film in use is 'Gevacolor N5' clear flash bulbs can also be used. If clear flash bulbs are to be used with 'Gevacolor R5' film then a blue 'Gevacolor CTB-8' filter must be used.

There are several pitfalls to be avoided when only flash illumination is used.

When taking close-up portraits with the flash mounted directly on the camera it is only too easy to over-expose the face and to get a dense black background. The photograph can be improved by placing the subject as close as possible to a light-coloured wall provided the flash is above the camera so the shadow cast is hidden behind the subject. To obtain a softer result the reflector can be covered with a diffusing disc (or even a white handkerchief), or you can use 'bounce' flash from the walls and ceiling alone.

Another very prevalent fault is a 'hot-spot', too great a concentration of light in the centre of the subject. This is caused by using a poor quality or a badly designed reflector. You should check this beforehand to see that it gives an even spread of light into the corners with black and white film because, although this fault is bad enough in ordinary work, it is far worse in colour.

EXPOSURE

'Gevacolor' films, of both reversal and negative types, have less exposure latitude than black and white films. It is of the greatest importance, therefore, that the exposure required should be determined carefully. Most people do this with an exposure meter which must, of course, be used correctly. Both the reflected and incident light methods are satisfactory provided you use them knowledgeably.

Here, first of all, are the recommended speed settings for various exposure meters.

'Gevacolor Negative N5':	17 DIN	40 ASA 3·5°
'Gevacolor Reversal R5':	18 DIN	50 ASA 4°
'Gevacolor Negative N3':	14 DIN	20 ASA 2·5°

Using these figures with most of the recent types of meters will give the best results.

It goes without saying that the same rules which apply to black and white photography hold also for colour work. They should, of course, be applied with more care, because, although you can count on large tolerances in black and white work, this is not the case with colour.

It is particularly useful to re-read carefully the instructions provided with the exposure meter and to remember the various points which are dealt with below and which apply particularly to colour photography.

Exposure meters measuring reflected light

These are the normal type of exposure meter that we are all used to. They measure the light reflected by the subject and the exposure is calculated automatically from this quantity.

If the subject is made up of roughly equal areas of light and shade then the indicated exposure will be correct. But this ceases to be the case if there is a predominance of either light or dark tones in the picture. Since a dark toned subject will give a low average reading asking for more exposure and a light toned subject a high average reading asking for less exposure, whereas if the lighting was the same in all three cases, and we wish to show *them as they really are*, then they should have the *same exposure*. The error is of course caused by the assumption in calibrating the meter that we should read the whole of the reflected light and that generally the average would be 'about right'. So it may be for the latitude available in black-and-white work, not so in colour. This fact must, therefore, be taken into account when calculating the exposure. If you are dealing with subjects which are extremely light (i.e. in snow, on the beach, or in subjects where yellow predominates) the stop indicated by the meter reading should be closed down by one stop (e.g. if the meter reading indicates *f*/8 use *f*/11). If, on the other hand, the subject is very dark (dark foliage, narrow streets, subjects in which blue predominates) the diaphragm should be opened up one-half of a full stop from the value indicated by the meter (e.g. use *f*/6.3 if the meter indicates *f*/8.)

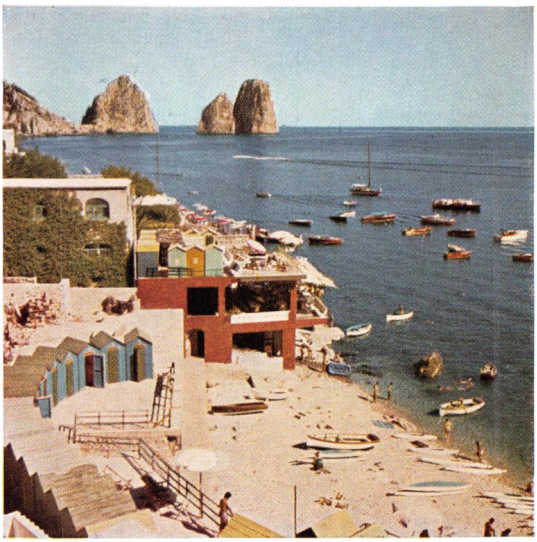
Do not forget that the angle embraced by the photocell of the meter is

Gevacolor Reversal
Photo W. Schmölcke



Gevacolor Negative
Photo F. Philippi

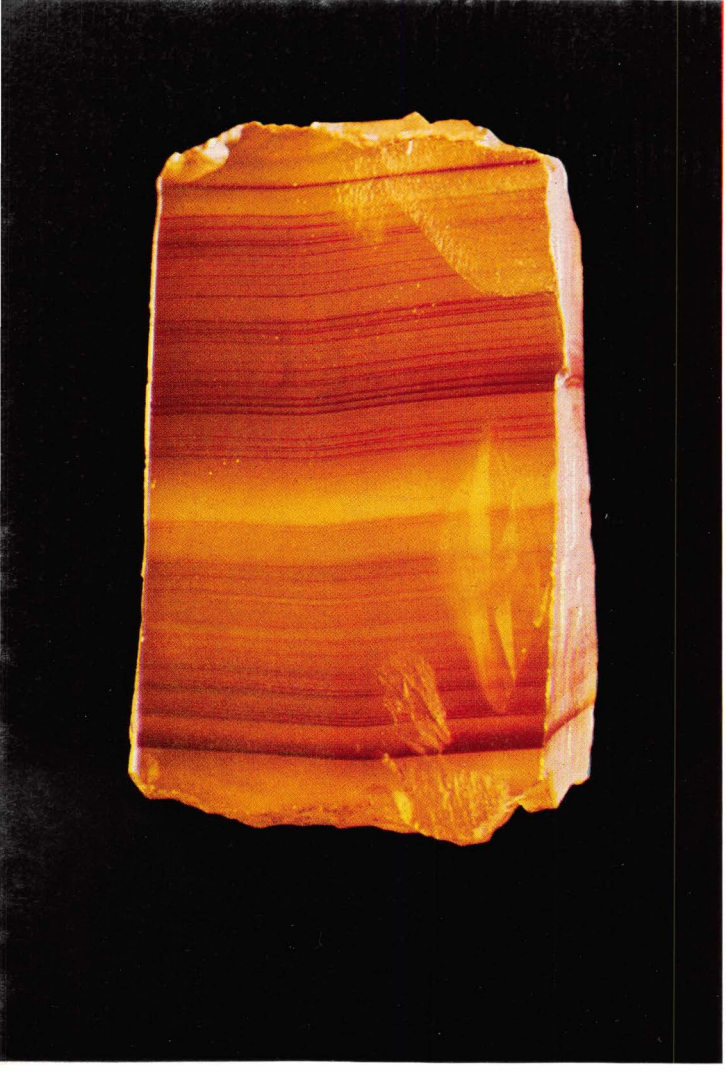




Gevacolor Reversal
Photo Gevaert Archives



Gevacolor Reversal
Photo F. Philippi



Gevacolor Reversal
Photo François Duyk

Uncut cornelian, showing parallel stratifications. Microscope lamp at 12 in., 1 sec. Blue filter.

Gevacolor Reversal
Photo François Duyk

Group of stones. 1 "Photolita"-lamp at 2 ft. 2 sec. Polarizing filter.



generally greater than that occupied by the principal subject. The reading will be in error then if the background is much lighter or darker than the subject itself. The meter, unless it is brought closer, measures the sum of the light reflected from both the subject and its background.

Now if it only occupies a small area of the picture it will hardly affect the meter reading at all. If the background happens to be very bright as compared to the subject the cell will as a consequence receive too much light and indicate too small a stop and the subject will then be under-exposed.

This is what happens, for example, when we want to photograph from a low viewpoint someone on a sand dune posed against a blue sky. If on the other hand the background is much darker than the subject then the subject itself will be over-exposed.

To overcome these difficulties it is better to come closer to the subject to make the measurement with the meter, so that the background has little or no influence on the cell.

Care must then be taken that part of the subject chosen is representative of the subject as a whole and not too dark or too light. To make such selection unnecessary, a neutral grey card can be used which reflects about 18% of the incident light. This value is the mean of the reflectances of most coloured objects.

The grey card is held in front of the subject (so it receives the same illumination) and the reading is made with the meter as close as possible to it, without, of course, casting any shadow on the card.

The exposure indicated by the meter is correct for all normal subjects. For subjects predominantly light in tone the diaphragm should be closed down one stop; for predominantly dark-toned subjects opened up half a stop. This is because in the first case the reflectance of the subject is nearer 36% than 18%. Since we have little dark shadow we can probably afford to ignore it and we can reproduce the fine shades of the subject better if we make a slightly darker transparency than would be the case with a 'normal' subject. So, although we darken all the tones they are separated out better. With the dark subject, however, the average reflectivity is somewhat lower than 18%, say 12%, and half a stop extra exposure will lighten the whole scene on the screen and reveal more details in the shadows which compose the greater part of the scene. The brightest highlights will of course be over-exposed and probably bleached out, but we are not worrying about these.

In dim light the reading can still be made on a white card. The indicated exposure must then be increased four or five times (e.g. if the exposure indicated is *f*/16 at 1/25th sec. then the stop should be reset to between *f*/8 and *f*/6.3 for 1/25th sec., or *f*/16 for 1/5th sec.). If you have no card then you can use your hand. Since, however, this reflects about 30% of the incident light, that is about twice as much as the average subject, the exposure indicated should be doubled (e.g. by using *f*/8 instead of an indicated *f*/11.)

Always remember that when you are using reversal colour films it is the highlights or lightest areas that must be correctly exposed, since during projection the attention is first drawn to them and the shadows are disregarded somewhat.



Photo : A. E. Lockington Vial

Further, the specular highlights should be clear film and the brightest true highlight should be almost clear so that it shows brightly on the screen. Otherwise you are throwing away light and overheating your slide. If you base your exposure on the shadows the highlights may be washed out if the subject contrast is high, or greyed over if the subject contrast is low.

Exposure meters measuring incident light

Although the method described is the best known, there is a newer method – the measurement of incident illumination – which has been used for more than ten years in the feature film studios and is being used more and more, especially for colour photography.

As the name implies, these meters measure the illumination incident on the scene and the exposure indicated is calculated from this quantity.

They are held in the subject position, and if they are fitted with a hemispherical diffuser over the cell, they are pointed towards the camera, and if fitted with a flat diffuser they are pointed midway between the camera axis and the main light source.

Obviously the quantity measured is quite independent of the lighting in the background (and to a large extent independent of effects lighting) and of the reflectance of the subject itself.

As in the case for readings taken with a reflected light meter on a grey card the incident light meter bases its calculations on an average or mean reflectance and for light and dark subjects it is necessary to close down or open up the indicated aperture by either half a stop or a full stop respectively.

There are of course times when incident light measurements are of no use. e.g. a sunset, a photograph through a window and whenever it is impossible to get close enough to the subject to measure *substantially* the illumination falling on it. Obviously it can be used for a landscape except when the meter position is under cloud shadow and the landscape not. In such cases the ordinary reflected light method should be used. Most modern exposure meters can, however, be easily changed so as to be suitable for either type of measurement.

Exposure tables

Gevaert Ltd. have prepared a small exposure table, very easy to use, for those who have no exposure meter. It can be obtained free from your normal supplier.

Guide numbers

Guide numbers for use with flash are given in Table O, Appendix No. 1 to Part VI of this manual.

How to preserve colour prints and colour slides

Contact prints and enlargements made of 'Gevacolor' paper are best mounted carefully in an album. It is well known that coloured objects exposed to bright

sunlight, and even weaker light, will fade after a time. The same thing happens with colour photographs – their emulsion layers are only 7/5000th in. thick and the dyes are exceedingly delicate so they should not be put up on walls where the light is bright.

'Gevacolor' transparencies should be mounted in slide frames. In this way they are safe from fingerprints and scratches. Take great care to make sure that both prints and slides are always kept in a cool dry place. It is not a good thing to keep them in a cupboard in the kitchen, or to leave them in a parked car in the sun, or near to radiators or hot pipes.

When projecting slides be sure not to let the projector overheat and cause them any harm. The cooling system – blower and heat filter – should be in perfect working order. A heat absorbing filter is advised. Do not be tempted to use a lamp of greater wattage than the projector is designed for. Do not leave the slides in the projector any longer than necessary.

FORMATION OF IMAGES ON 'GEVACOLOR'

NEGATIVE POSITIVE PROCESS

'Gevacolor' films (negative and reversal) have three sensitive layers, A, B and C, and a black antihalo layer D, all coated on a flexible clear base E. (Negative roll films have a green antihalo layer on the back of the base in place of the black antihalo layer D). The total thickness of these layers is, it should be noted, of the same order as the thickness of an ordinary emulsion for black-and-white photography.

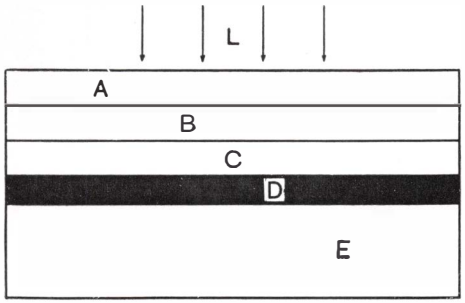


Fig. 106 Vertical section through 'Gevacolor' film (diagrammatic).

During the exposure the incident light L traverses successively:

- layer A is sensitive to blue, and it is yellow in colour to absorb all blue rays thus preventing these from reaching the lower layers as these are also sensitive to blue;
- layer B sensitive to green;
- layer C sensitive to red.

Any light which penetrates further is totally absorbed by the antihalo layer which becomes completely transparent during processing.

'Gevacolor' negative films are developed directly in a colour developer. This development produces in the three sensitive layers – each of which contains a specific coupler or colour former – along with the negative silver image a *negative image in complementary colours*. These record in turn blue light (A), green (B) and red (C) and are coloured, therefore, yellow (A), magenta (B) and cyan (blue-green) (C).

Because of the high silver image density these colours are not visible. The black silver image of layers A, B and C, and the yellow colour of layer A are removed in the bleaching and fixing-clearing baths while the dye images are left intact. The three superimposed dye layers make up the colour negative in complementary colours, the blue areas of the subject being yellow on the negative, the green areas magenta and the red areas cyan.

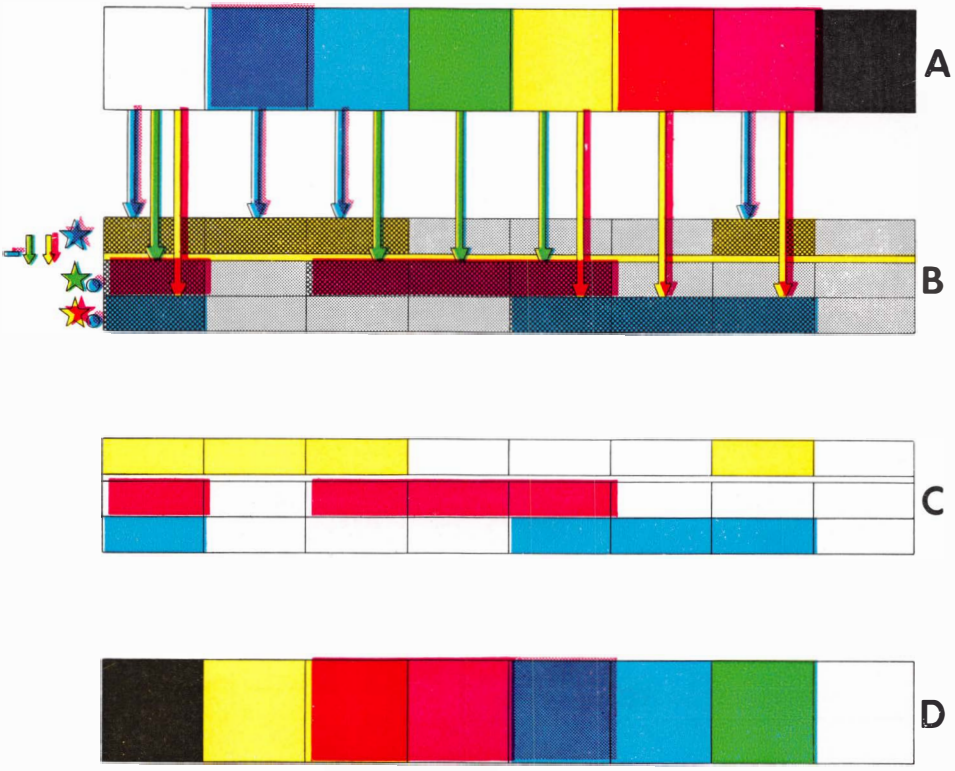


Fig. 107 Formation of positive images on 'Gevacolor' paper from a subject composed of patches of the following colours:

WHITE | BLUE | CYAN | GREEN | YELLOW | RED | MAGENTA | BLACK

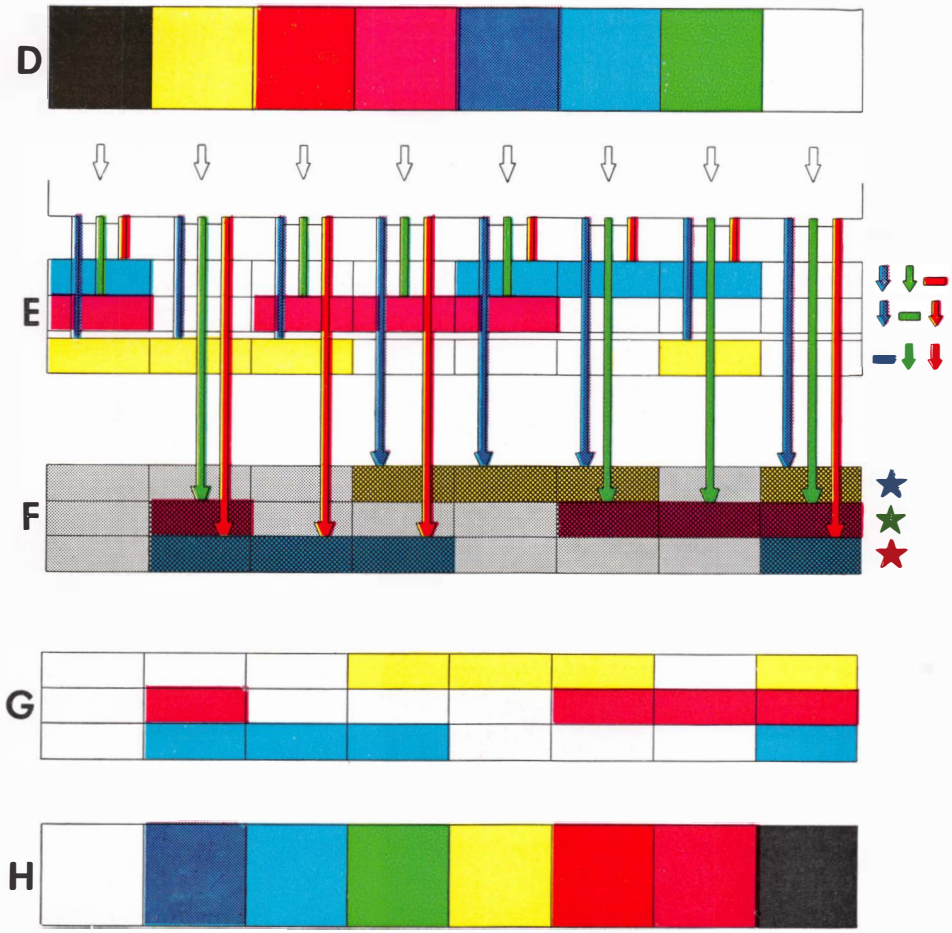
Emulsion layer.

Emulsion blackened and dyed in colour development.

The long arrows indicate the colour composition and the action of light rays from the subject (above) or the printer or enlarger (right-hand page).

The colour of the small horizontal bars indicates which rays are absorbed by the yellow coloured layer (above) or by the image in the three layers of the negative (right-hand) page.
The small coloured arrows indicate which rays are able to pass through the yellow filter or the three images.
The small white arrows (right-hand page) represent the white light of the printer or enlarger. The stars and dots show to which colours each layer is sensitive.

B, C, E, F and G show the three emulsion layers of 'Gevacolor Negative' film and 'Gevacolor' paper, in diagrammatic form.



A: Subject.

B: Negative film after colour development.

C: Negative film after completion of processing.

D: Negative image (Plan View).

E: Negative film in printer or enlarger.
The blue, green and red light which go to make up white light is absorbed selectively by the three coloured image layers. Other shades and mixtures of colours which are not shown here are produced by one or more of the layers being only partly dyed and so only absorbing some of its specific component of the incident light.

F: Positive image on paper after colour development.

G: Positive image on paper after completion of processing.

H: Positive image on paper in natural colours (viewed by reflected light) (Plan view).

Printing the positive

This complementary coloured negative is then contact printed or enlarged on to 'Gevacolor' paper. This, like the films, has essentially three sensitive emulsion layers A, B and C sensitized to blue, green and red respectively and coated on to the support D (see fig. 108).

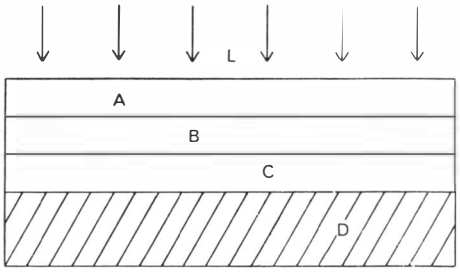


Fig. 108 Section through 'Gevacolor' paper (diagrammatic).

Unlike the films, 'Gevacolor' paper has no yellow filter layer as the sensitization of the layers is arranged so that blue light has little or no effect on the two underneath layers B and C. The various stages of processing 'Gevacolor' paper are the same as for the colour negative in film. After the colour-coupling development the same yellow, magenta and cyan dyes respectively are formed in the three layers. With a complementary coloured negative this gives a second colour switch and the original colours of the subject now reappear on the positive paper print.

It is not within the scope of this manual to deal completely with the technique of printing 'Gevacolor Negative' film on to 'Gevacolor' paper.

It is sufficient for us to say that the satisfactory and faithful reproduction of colours is by no means an automatic process and a good deal of experience and training is necessary. For this reason Gevaert who realize the need for consistent first class quality reserve the right to supply 'Gevacolor' paper and the detailed instructions for handling it only to specialized colour-printing laboratories.

Processing

For those who would nevertheless like to have some idea of the process, it is outlined below.

Many factors can affect the colour rendering. Amongst the most important factors are the colour temperature, the exposure level and the way processing is carried out. The least deviation in any one of these factors may produce a dominant colour cast over the whole picture.

Actually whatever the primary cause for the cast, it can always be traced to one or two of the emulsion layers having been exposed excessively relative to the other(s). The cast can thus be corrected by modifying the spectral composition of the printing light.

This may be done in two ways; one of the methods is subtractive, the other additive. It must be borne in mind what has been said above regarding subtractive and additive methods.

The *subtractive* method consists in the use of three filters in the complementary

colours, yellow, magenta and cyan, which each absorb one section of the spectrum. One thus *subtracts* a portion of the white light coming from a *single white light source*. The same applies in the subtractive printing of a colour positive. Only a single source of white light is used and its colour composition is altered by inserting yellow, magenta or cyan correction filters of different densities.

The *additive* method on the other hand consists in the projection of *three beams of light*, red, green and blue, in such a way that by their *addition* all the other colours are formed. The same principle applies in the additive printing of colour positives. In the printing apparatus three sources of light are used which are red, green and blue and which are obtained by the use of special colour selective filters. By varying their relative intensities the spectral composition of the printing light can be varied. The processing of negative films and of paper is carried out exclusively in laboratories specially equipped for this purpose. Here is an outlined description of the different operations. It is given for the purpose of illustration and is subject to modification.

Processing tables

'Gevacolor Negative' films

Operation	*Time*
Colour development	10½ min.
Washing	30 sec.
Hardening-fix	8 min.
Washing	15 min.
Bleaching	5–8 min.
Washing	5 min.
Fixing	5 min.
Washing	20 min.
Drying	—

'Gevacolor' paper

Operation	*Time*
Colour development	5 min.
Washing	30 sec.
Fixing	5 min.
Washing	10 min.
Bleach-fix	5 min.
Washing	10 min.
Colour stabilization	5 min.
Glazing without washing	—

REVERSAL PROCESS

'Gevacolor Reversal' films have similar emulsion layers to 'Gevacolor Negative' films; the three layers are affected in the same way when exposed. Unlike the negative films, however, the reversal films are developed first in a black-and-white developer which produces in each of the three emulsion layers only black negative images which correspond (see fig. 106) to the blue (A), green (B) and red (C) rays respectively.

This first development is then arrested in a stop bath and the film is re-exposed uniformly to artificial light. In the subsequent colour development those areas which have not been developed in the first developer are changed to silver and at the same time in these parts of each emulsion layer there is formed by the

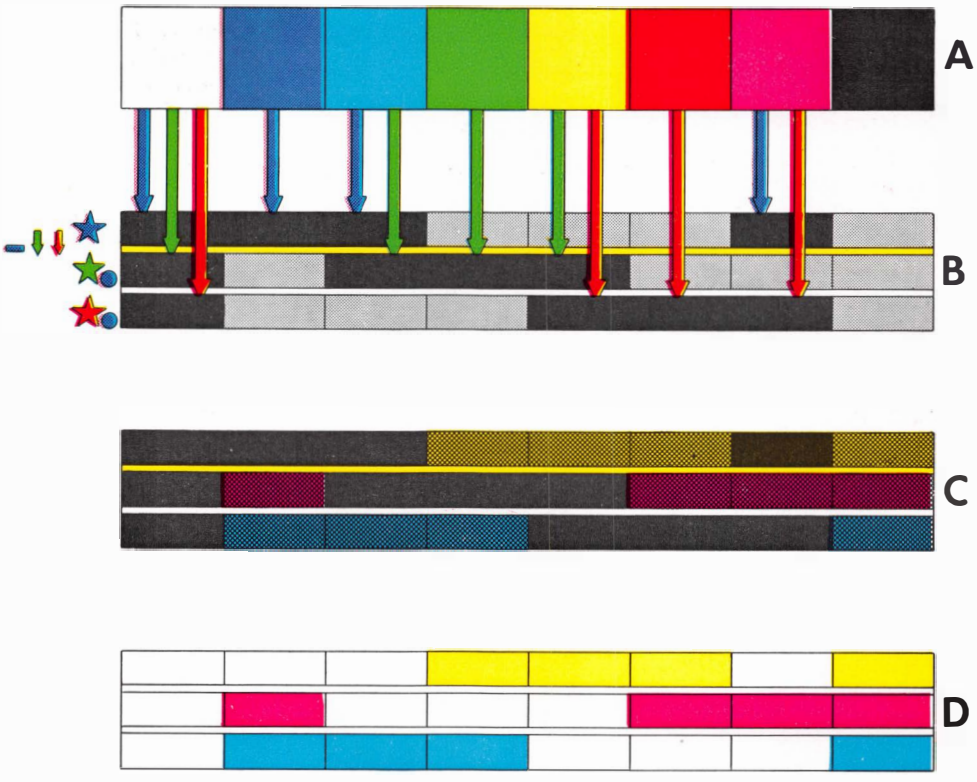


Fig. 109 Formation of transparent colour images on 'Gevacolor Reversal' from a subject composed of patches of the following colours:

WHITE | BLUE | CYAN | GREEN | YELLOW | RED | MAGENTA | BLACK

Emulsion layer.

Emulsion blackened in first development.

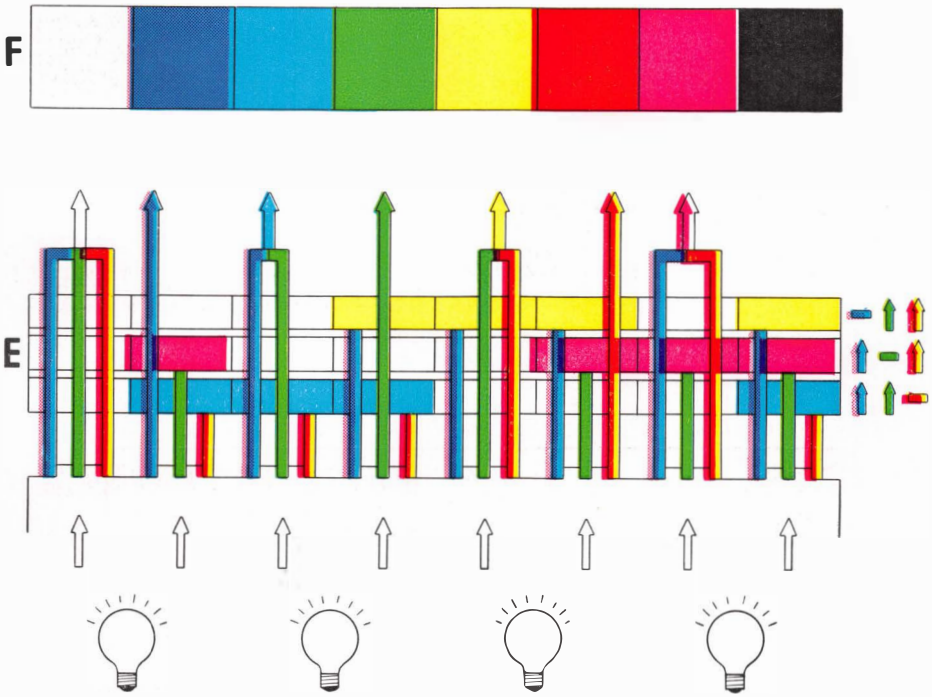
Emulsion blackened and dyed by colour development.

The long arrows indicate the colour composition and the action of light rays from the subject (above) or projector (right-hand page).

The colour of the small horizontal bars indicates which rays are absorbed by the yellow filter (above) or by the image in the three layers (right-hand page).

The small coloured arrows indicate which rays are able to pass through the yellow filter or the three images.

The small white arrows (right-hand page) represent the white light in the projector. The stars and dots show to which colours each layer is sensitive.



A: *Subject (Plan view).*
B, C, D and E show the three emulsion layers of 'Gevacolor Reversal' film in diagrammatic form.

B: *After exposure and first development.*

C: *After colour development.*

D: *After completion of processing.*

E: *The film in the projector or viewed by transmitted light.*
The blue, green and red rays of which the white light is composed are selectively absorbed by the three dye layers. Intermediate tints not shown here are reproduced by partially dyed layers which only partially absorb the incident light.

F: *Image as projected (or viewed by transmitted light).*

action of the colour couplers, a dye image in complementary colours, i.e. a yellow (A), magenta (B) and cyan (C) image which together form a *positive image in natural colours.*

The black silver in the emulsion layers A, B, C, D, and the yellow colloidal silver in the filter layer are then removed in baths which leave the colour images in the three layers intact.

Processing of 'Gevacolor Reversal' films

Like 'Gevacolor Negative' films, 'Gevacolor Reversal' films are processed exclusively in specialized laboratories.

In the table below is given an outline of the various operations for processing 'Gevacolor Reversal R5' film. This description is given for the purpose of illustration only and is subject to modification.

Operation	*Time*
First development	(*)
Washing (thorough)	30 sec.
Hardening stop-bath	3 min.
Washing	3 min.
Exposure to white light	1 min.
Washing	7 min.
Colour development	(*)
Washing	30 sec.
Hardening fix	5 min.
Washing	15 min.
Bleaching	7 min.
Washing	5 min.
Fixing	5 min.
Washing	15 min.
Drying	—

(*) Time indicated for every emulsion number.

PART FIVE

PHOTOGRAPHIC CHEMICALS

Chemicals
Photographic Formulae
Hints and Recipes

GEVAERT PHOTOGRAPHIC CHEMICALS

The amateur photographer is the one who derives most benefit from having ready to hand the right amount of this or that processing solution. He takes up photography as a pastime and has to use the leisure time he has free from work. He generally works sporadically and some time may elapse between his successive visits to the darkroom. To avoid having large amounts of solutions which have been made up deteriorating during these periods of inactivity Gevaert have specially marketed a range of photographic chemical preparations which can be dissolved completely or partly, and diluted when required, so that you need not make up any more solution than you actually require at any particular time. Obviously much time, trouble and money can be saved in this way.

The professional photographer too often finds it advantageous to use prepacked photographic chemicals. This is particularly so with special developers and fine grain developers for which ordinary keeping properties are not sufficient.

Developers of these types supplied by Gevaert are of first class quality and are sold in quantities suited to all types of user.

The necessary preservatives are included, as well as the additional chemicals needed to bring the solutions up to their correct activity.

The name of Gevaert on the package, it goes without saying, guarantees for professional and amateur alike the best quality. Ideal factory conditions and the handling of large quantities of any particular item assure a dependable standardized product and the name of Gevaert means that there is a strict control over both the raw materials used and the final products.

The formulae and recipes given below are intended solely for use in black-and-white photography. The processing of colour films such as 'Gevacolor Negative' and 'Gevacolor Reversal' is carried out only in special laboratories equipped for the purpose. Gevaert supply these laboratories with all the necessary chemicals for processing these films.

Notes

Unless otherwise stated all the products mentioned here are supplied in powder form.

The development time is given for each developer in two forms:

(*a*) For tray development = continuous agitation.

(*b*) For tank development = agitation for about the first 30 seconds and thereafter for 5 seconds every 2 minutes.

To convert tray times to tank times and vice versa:

Tray times = tank times *less* 25%.

Tank times = tray times *plus* 30%.

GEVAERT DEVELOPERS

'Refinex'

A fine-grain developer which does not reduce emulsion speed. A standard developer for roll films, miniature films and plates. Supplied in 1, 10, 45 and 70 litre packs.

Development times at 68°F. (20°C.):	*Tray*	*Tank*
Roll and miniature films, all kinds	6½ min.	8½ min.
Plates: 'Gevachrome 32' and 'Gevapan 30'	10 min.	13 min.
'Gevapan 33'	14 min.	18 min.
'Replica 23'	6 min.	8½ min.

Separate packings of Replenisher 'Refinex-R' to make 10 or 50 litres of solution are available for professional use.

'Gevafin'

'Gevafin' is a fine grain developer which does not require any increase in exposure; on the contrary in the case of subjects of normal contrast (1 : 50) it is advisable to shorten the exposure by half, either by doubling the shutter speed or by reducing the diaphragm aperture by one stop. The primary characteristic of 'Gevafin' is indisputably the fact that in relation to the gradation the increase of speed is more rapid without the graininess or the fog being considerably influenced. 'Gevafin' is also a compensating developer. Negatives developed in 'Gevafin' do record subjects of great contrast in such a way that the highlights and the deep shadows retain their full detail which can be easily reproduced in printing.

'Gevafin' developer is supplied in powder form packed in quantities to make 600 c.c. or 750 c.c. of working solution.

	Tray	*Tank*
Development times at 68°F. (20°C.):	15 min.	20 min.

'Nogranol'

Ultra fine grain developer. Particularly recommended for roll films and miniature films which are to be considerably enlarged. Needs 50% more camera exposure than an ordinary MQ developer (i.e. emulsion speed reduced to two-thirds normal.)

Supplied in packings to make 7½ and 35 litres working solution.

Development times at 68°F. (20°C.):	*Tray*	*Tank*
Roll and miniature films, all kinds	10 min.	13 min.

'Nogranol-R' replenisher is available in packs to make 10 litres of solution for professional use.

'Studio Normal'

Developer for sheet film. For normal and contrasty results. To make 12 litres of solution.

Development times at 68°F. (20°C.):	*Tray*	*Tank*
Sheet films: 'Gevachrome 32', 'Gevapan 30' and 'Gevapan 33'	4 min.	5 min.
'Gevapan 36'	6 min.	8 min.

'Studio Normal Replenisher' is supplied separately. Packing to make 3 litres of replenisher solution.

'Studio Special'

Developer for sheet film and plates. For normal and soft results. Compensating developer. Equally suitable for obtaining increased emulsion speed by prolonged development. 12 litre packing.

Development times at 68°F. (20°C.):	*Tray*	*Tank*
Sheet films: 'Gevachrome 32', 'Gevapan 30' and 'Gevapan 33'	7 min.	9 min.
Plates: 'Gevachrome 32' and 'Gevapan 30'	4 min.	5 min.
'Gevapan 33'	5 min.	6½ min.
'Gevapan 36'	8½ min.	11½ min.

'Studio Special Replenisher' is supplied separately in packs to make 3 litres of replenisher solution.

'Metinol-U'

Universal developer, particularly recommended for developing every kind of photographic paper. In packings to make 1, 2½, 5, 10 and 25 litres of solution.

Development times at 68°F. (20°C.):	*Tray*
Papers: 'Ridax', 'Artona'	1 min.
'Vittex', 'Gevatone'	1–1½ min.
'Gevarto', 'Gevabrom'	1½–2 min.
Plates: 'Replica'	3 min.
'Diapositive Normal'	3–4 min.
'Diapositive Contrast'	3–4 min.

'Metinol-B'

Developer giving blue-black tones with 'Ridax' contact paper. Packings to make 5 and 25 litres.

Development time at 68°F. (20°C.): 1 minute.

GEVAERT FIXER

'Acidofix'

Universal fixing bath for films, plates and papers. Packings for 1 and 5 litres of working solution.

Fixing times:	
Films and plates	10–20 min.
Papers, general	5–10 min.

OTHER GEVAERT CHEMICALS AND SUNDRIES

'Gevatol' liquid wetting agent

Solutions containing 5–10 parts per thousand (½–1%) of 'Gevatol' wet evenly, i.e. without forming drops on the surface wetted. If, after washing, films, plates or papers are immersed in water containing 5–10 c.c. per litre of 'Gevatol' for

2 minutes and are then put aside to dry the water runs off evenly, drying is speeded up, and no drying marks are caused.

The addition of 5–10 parts per thousand (½–1 %) of 'Gevatol' to the developer helps it to wet the emulsion evenly and no air bells are formed on the surface as it is put into the solution. Small areas or spots which are not developed properly are thus avoided.

'Gevatol' is also useful whenever an even wetting of a surface is required. It can be added, for example, to retouching solutions, to water colours, gouache pigment, and so on.

'Vittol'

Toning solution for use with chlorobromide papers which does not need a preliminary bleaching. Particularly recommended for 'Vittex' paper with which it gives a very pleasant sepia tone.

Packings to make 50, 500 c.c. of concentrated stock solution, which is diluted with 9 parts of water for use.

'Etranol'

Cleaning fluid for amateurs' cine films or miniature films. Bottles of 100 c.c.

'Cinécol'

Film cement for joining all types of film. Bottles containing 30 c.c. and 1 litre.

'Gevacol'

For mounting photographs. Ordinary pastes often attack the photographic image after some time, forming stains and spots in places where the paste has been applied. The composition of 'Gevacol' prevents this and, in addition, 'Gevacol' is easy and clean to use.

RECOMMENDED DEVELOPERS

★ Roll films and miniature films
Standard fine grain developers: 'Gevafin', 'Refinex' or formula G.206.
Ultra fine grain developers: 'Nogranol' or formula G.224.

★ Sheet film
Normal contrast developer: 'Studio Normal' or formula G.214.
Soft: 'Studio Special' or formula G.215.

★ Plates
'Studio Special' or formula G.215.
'Refinex' or formula G.206.

★ Papers
'Metinol U' or formula G.251.
'Metinol B' or formula G.252 ('Ridax' only).

PHOTOGRAPHIC FORMULAE

Dissolve the chemicals in the order listed. *Make sure* each is completely dissolved before the next is added. In each case the crystalline salt is specified and the equivalent amount of anhydrous salt is given in brackets afterwards. Always use pure, good quality chemicals which have been kept in tightly stoppered bottles. Discard dirty, discoloured or deliquescent materials.

DEVELOPERS FOR FILMS AND PLATES

For each of the developer formulae below are given the development times for tray and tank. The times stated are only average values for different types of films and plates and as a consequence should only be regarded as approximations.

G.206

Fine grain developer. Requires no increase in exposure. Standard developer for roll and miniature films.

	B. Imp.	*Metric*	*U.S.A.*
Water 100°F. (40°C.)	30 oz.	750 c.c.	24 oz.
Metol	35 gr.	2 gms.	30 gr.
Sodium sulphite, anhyd.	4 oz.	100 gms.	3 oz. 145 gr.
Hydroquinone	70 gr.	4 gms.	60 gr.
Borax	35 gr.	2 gms.	30 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

Mixing instructions: Dissolve in the following order: metol, about 10 gm. sulphite (cryst.), hydroquinone, borax, and then the rest of the sulphite.

Development times at 68°F. (20°C.):	*Tray*	*Tank*
Roll films and miniature films, all kinds	10 min.	13 min.
Plates: 'Gevachrome 32', and 'Gevapan 30'	10 min.	13 min.
'Gevapan 33'	14 min.	18 min.
'Replica 23'	6 min.	8½ min.

G.214

A normal contrast developer suitable for sheet films.

	B. Imp.	*Metric*	*U.S.A.*
Water 100°F. (40°C.)	30 oz.	750 c.c.	24 oz.
Metol	35 gr.	2 gms.	30 gr.
Sodium sulphite, anhyd.	1 oz.	25 gms.	365 gr.
Hydroquinone	55 gr.	3 gms.	45 gr.
Sodium carbonate, anhyd.	280 gr.	16 gms.	230 gr.
or monohyd	¾ oz.	19 gms.	½ oz. 55 gr.
Potassium bromide	18 gr.	1 gm.	15 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

Development times at 68°F. (20°C.):	*Tray*	*Tank*
Sheet films: 'Gevachrome 32', 'Gevapan 30' and 'Gevapan 33'	4 min.	5 min.
'Gevapan 36'	6 min.	8 min.

G.215

For sheet films and plates. Gives maximum speed and normal to soft results (compensating developer).

	B. Imp.	*Metric*	*U.S.A.*
Water 100°F. (40°C.)	30 oz.	750 c.c.	24 oz.
Metol	70 gr.	4 gms.	60 gr.
Sodium sulphite, anhyd.	1 oz.	25 gms.	365 gr.
Sodium carbonate, anhyd.	175 gr.	10 gms.	145 gr.
or monohyd.	210 gr.	12 gms.	175 gr.
Potassium bromide	9 gr.	½ gm.	7½ gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

Development times at 68°F. (20°C.):	*Tray*	*Tank*
Sheet films (not 'Gevapan 36')	7 min.	9 min.
Plates: 'Gevachrome 32' and 'Gevapan 30'	4 min.	5 min.
'Gevapan 33'	5 min.	6½ min.
'Gevapan 36'	8½ min.	11½ min.

G.222A – For use in the tropics

For films and plates.

	B. Imp.	*Metric*	*U.S.A.*
Water 100°F. (40°C.)	30 oz.	750 c.c.	24 oz.
Metol	35 gr.	2 gms.	30 gr.
Sodium sulphite, anhyd.	2 oz.	50 gms.	1 oz. 292 gr.
Hydroquinone	90 gr.	5 gms.	75 gr.
Sodium sulphate, anhyd.	1¾ oz.	45 gms.	1½ oz.
Potassium carbonate	1¼ oz.	30 gms.	1 oz.
Potassium bromide	25 gr.	1½ gm.	22 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

Development times: Tray 1½ min. at 86°F. (30°C.)
Tank 2 min. at 86°F. (30°C.)

N.B. After processing in this developer, the film or plate should be transferred first to a stop bath (e.g. G.357) and then to an acid-hardening fixing bath (e.g. G.308).

G.223 – For use in the tropics

An ultra-fine-grain developer for films and plates. (This developer requires a 100% increase in camera exposure.)

	B. Imp.	*Metric*	*U.S.A.*
Water 100°F. (40°C.)	30 oz.	750 c.c.	24 oz.
Metol	90 gr.	5 gms.	75 gr.
Sodium sulphite, anhyd.	2 oz.	50 gms.	1 oz. 292 gr.
Borax	90 gr.	5 gms.	75 gr.
Sodium sulphate, anhyd.	2 oz.	50 gms.	1 oz. 292 gr.
Potassium thiocyanate	18 gr.	1 gm.	15 gr.
Potassium bromide	18 gr.	1 gm.	15 gr.
Phenol	6 minims	5 drops	5 minims
Water, to make	40 oz.	1,000 c.c.	32 oz.

Development times: Tray 9 min. at 86°F. (30°C.)
Tank 12 min. at 86°F. (30°C.)

N.B. After processing in this developer, the film or plate should be transferred first to a stop bath (e.g. G.357) and then to an acid-hardening fixing bath (e.g. G.308).

G.224

This developer produces a very fine grain on roll films and miniature films, but an increase in exposure of 100% is required.

	B. Imp.	*Metric*	*U.S.A.*
Water 100°F. (40°C.)	30 oz.	750 c.c.	24 oz.
Metol	¼ oz.	6 gms.	88 gr.
Sodium sulphite, anhyd.	3½ oz.	90 gms.	3 oz.
Borax	55 gr.	3 gms.	45 gr.
Potassium thiocyanate	18 gr.	1 gm.	15 gr.
Potassium bromide	9 gr.	½ gm.	7½ gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

Note. – If the tap-water is very chalky, it is preferable to use distilled water for preparing this developer.

Development times at 68°F. (20°C.):

Tray	16 min.
Tank	21 min.

DEVELOPERS FOR PAPERS

G.251

A universal normal contrast developer.

	B. Imp.	*Metric*	*U.S.A.*
Water 100°F. (40°C.)	30 oz.	750 c.c.	24 oz.
Metol	25 gr.	1½ gm.	22 gr.
Sodium sulphite, anhyd.	1 oz.	25 gms.	365 gr.
Hydroquinone	¼ oz.	6 gms.	88 gr.
Sodium carbonate, anhyd.	700 gr.	40 gms.	1 oz. 145 gr.
or monohyd.	1¾ oz.	45 gms.	1½ oz.
Potassium bromide	18 gr.	1 gm.	15 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

Development time at 68°F. (20°C.):	*Tray*
'Ridax', 'Artona'	1 min.
'Gevatone', 'Vittex'	1 to 1½ min.
'Gevarto', 'Gevabrom'	1½ to 2 min.
'Replica 23' – plate	3 min.
'Diapositive' – plates	3 to 4 min.

This developer, diluted with an equal quantity of water, will give softer results provided that the exposure time is increased and the development time remains unaltered.

G.252

Developer for blue-black tones on 'Ridax' paper.

	B. Imp.	*Metric*	*U.S.A.*
Water 100°F. (40°C.)	30 oz.	750 c.c.	24 oz.
Metol	45 gr.	2½ gms.	37½ gr.
Sodium sulphite, anhyd.	1 oz.	25 gms.	365 gr.
Hydroquinone	¼ oz.	6 gms.	88 gr.
Sodium carbonate, anhyd.	700 gr.	40 gms.	1 oz. 145 gr.
or monohyd.	1¾ oz.	45 gms.	1½ oz.
Potassium bromide	9 gr.	½ gm.	7½ gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

Development time at 68°F. (20°C.): 1 minute

G.253

Paper developer for soft results.

	B. Imp.	*Metric*	*U.S.A.*
Water (110°F.)	30 oz.	750 c.c.	24 oz.
Metol	55 gr.	3 gms.	45 gr.
Sodium sulphite, anhyd.	350 gr.	20 gms.	292 gr.
Sodium carbonate, anhyd.	350 gr.	20 gms.	292 gr.
Potassium bromide	18 gr.	1 gm.	15 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.
Development times at 68°F. (20°C.):			
'Ridax'			1 min.
'Gevatone', 'Vittex'			1 to 1½ min.
'Gevarto', 'Gevabrom'			1½ to 2 min.

The stock solution may also be used diluted with an equal part of water, the development times given will then need to be increased somewhat.

G.261

Developer for brown and red tones on 'Vittex' paper.

	B. Imp.	*Metric*	*U.S.A.*
Water 100°F. (40°C.)	30 oz.	750 c.c.	24 oz.
Sodium sulphite, anhyd.	1½ oz.	40 gms.	1 oz. 145 gr.
Glycin	¼ oz.	6 gms.	88 gr.
Hydroquinone	¼ oz.	6 gms.	88 gr.
Sodium carbonate, anhyd.	1¼ oz.	30 gms.	1 oz.
or monohyd.	600 gr.	35 gms.	1 oz. 75 gr.
Potassium bromide	35 gr.	2 gms.	30 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

Undiluted this developer gives warm black tones. Development time at 68°F. (20°C.) about 2–3 mins. By diluting the solution the following effects can be obtained.

Image Tone	*Dilution with parts of water*	*Development time at 68°F. (20°C.)*
Brown	1–2	4– 8 min.
Red-brown	3–4	7–15 min.
Red	5–6	15–25 min.

The development times given above are only approximate. In practice the development times depends both on the negative and the type of result required. The following facts are worth bearing in mind:

1. The image tone tends to become warmer as development is prolonged and with progressive dilutions of the developer.
2. The exposure required (i.e. the paper speed) is constant, whatever the dilution of the developer.
3. The development times decrease and the tone becomes warmer as the temperature of the solution is raised.
4. If even warmer tones are required add 10 grams per litre of sodium bicarbonate to the solution.

G.262

For warm black and brown tones on 'Vittex' and 'Gevatone'.

★ Stock solution

	B. Imp.	*Metric*	*U.S.A.*
Water 100°F. (40°C.)	30 oz.	750 c.c.	24 oz.
Sodium sulphite, anhyd.	2¾ oz.	70 gms.	2 oz. 145 gr.
Hydroquinone	1 oz.	25 gms.	365 gr.
Potassium carbonate	3½ oz.	90 gms.	3 oz.
Potassium bromide	35 gr.	2 gms.	30 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

Dilute for use with from 2 to 6 parts of water according to the image tone required (from warm black to red.)

Approximate development times at 68°F. (20°C.) from 2–6 minutes.

This developer gives the same image tones as the preceding G.261 but requires from 1½ to 4 times the exposure required for development in a normal developer (such as G.251).

FIXING BATHS

Note

Where hypo., sodium thiosulphate, is called for, the weights given are for the crystalline form (the decahydrate $Na_2S_2O_3 10H_2O$) not the monohydrate, or anhydrous form. If the anhydrous powder is used then take 60% of the quantities indicated. Sodium thiosulphate is sometimes called sodium hyposulphite, especially in older books (hence the popular name hypo).

G.301 – Acid fixer

For plates, films and papers.

	B. Imp.	*Metric*	*U.S.A.*
Water (85°F.)	30 oz.	800 c.c.	24 oz.
Sodium thiosulphate (hypo)	8 oz.	200 gms.	6¾ oz.
Sodium metabisulphite or Sodium bisulphite	1 oz.	25 gms.	365 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

For tank development, or machine development where more rapid fixing is desired the quantity of sodium thiosulphate may be increased by 50%.

G.303 – Acid hardening fixer

Acid fixer with chrome alum hardener for films and plates.

★ Stock solution A

	B. Imp.	*Metric*	*U.S.A.*
Water 85°F. (30°C.)	24 oz.	600 c.c.	19½ oz.
Sodium thiosulphate (hypo)	8 oz.	200 gms.	6 oz. 290 gr.
Potassium metabisulphite	1 oz.	25 gms.	365 gr.
Water, to make	30 oz.	750 c.c.	24 oz.

★ Stock solution B

Water	10 oz.	250 c.c.	8 oz.
Chrome alum	90 gr.	5 gms.	75 gr.

For use take 3 parts of A and add 1 part of B (by volume). If a more rapid fixing bath is required the quantity of thiosulphate may be increased by 50%. Formulae containing chrome alum do not keep well after use.

G.304 – Rapid fixer

For films and plates, especially press work.

	B. Imp.	*Metric*	*U.S.A.*
Water 85°F. (30°C.)	30 oz.	750 c.c.	24 oz.
Sodium thiosulphate (hypo)	12 oz.	300 gms.	10 oz.
Potassium metabisulphite	1 oz.	25 gms.	365 gr.
Ammonium chloride	2 oz.	50 gms.	1 oz. 292 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

G.305 – Acid fixer

For films and plates. This fixing bath can be converted into a hardening fixer by the addition of G.305H liquid hardener solution.

	B. Imp.	*Metric*	*U.S.A.*
Water (85°F. or 30°C.)	30 oz.	750 c.c.	24 oz.
Sodium thiosulphate (hypo)	8 oz.	200 gms.	6 oz. 290 gr.
Sodium sulphite, anhyd.	½ oz.	12 gms.	175 gr.
Potassium metabisulphite	½ oz.	12 gms.	175 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

When a rapid fixing bath is required, the quantity of sodium thiosulphate (hypo) may be increased by 50%.

G.305H – Hardener solution

	B. Imp.	*Metric*	*U.S.A.*
Water (85°F. or 30°C.)	6 oz.	150 c.c.	4¾ oz.
Sodium sulphite, anhyd.	125 gr.	7 gms.	100 gr.
Acetic acid (28%).	1½ oz.	40 c.c.	1¼ oz.
Potassium alum	260 gr.	15 gms.	½ oz.

The above quantity of solution, when cool, should be added slowly and with continual stirring to 40 oz. (B. Imp.) or 1,000 c.c. (Metric) or 32 oz. (U.S.A.) of the acid-fixer No. G.305.

G.308 – Acid hardening fixer

For films and plates.

	B. Imp.	*Metric*	*U.S.A.*
Water (85°F. or 30°C.)	30 oz.	750 c.c.	24 oz.
Sodium thiosulphate (hypo)	12 oz.	300 gms.	10 oz.
Potassium metabisulphite	210 gr.	12 gms.	175 gr.
Acetic acid (28%)	1¾ oz.	45 c.c.	1½ oz.
Borax	350 gr.	20 gms.	290 gr.
Potassium alum	260 gr.	15 gms.	½ oz.
Water, to make	40 oz.	1,000 c.c.	32 oz.

When a rapid fixing bath is needed, the quantity of sodium thiosulphate (hypo) may be increased by 50%.

It is advisable not to fix more than 1,600 sq. in., i.e. 120 ¼-plates or 20 of the 120 size of roll film per litre of fixer.

STOP BATHS AND HARDENING BATHS

G.351

	B. Imp.	*Metric*	*U.S.A.*
Acetic acid (28%)	2 fl. oz.	50 c.c.	1·6 fl. oz.
Water, to make	40 oz.	1,000 c.c.	32 oz.

G.352

	B. Imp.	*Metric*	*U.S.A.*
Potassium metabisulphite	2 oz.	50 gms.	1 oz. 290 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

G.354

For plates, films and papers. For use after fixing.

	B. Imp.	*Metric*	*U.S.A.*
Formalin (40%)	2 fl. oz.	50 c.c.	1·6 fl. oz.
Water, to make	40 oz.	1,000 c.c.	32 oz.

Immerse for between 10 and 20 minutes.

Formalin, a 40% solution of formaldehyde in water, is a powerful tanning agent, and acts upon the skin and, if allowed to be smelled, also upon the mucous membranes of the nose. This hardening bath is especially recommended when a negative is to be subjected to various chemical treatments such as reduction, intensification, etc. It is also useful in tropical climates as traces of formalin inhibit the growth of mould and bacteria.

G.356

For films and plates *only*. *Not* for papers!

	B. Imp.	*Metric*	*U.S.A.*
Chrome alum	350 gr.	20 gms.	290 gr.
Water, to make	40 oz.	1,000 c.c.	23 oz.

Time of use 5 minutes. Keep the film or plate on the move for the first minute. Discard the used solution as soon as it loses its fresh clear green look.

G.357

For films and plates – to be used after development in a tropical developer (e.g. G.222A or G.223).

	B. Imp.	*Metric*	*U.S.A.*
Water	30 oz.	750 c.c.	24 oz.
Sodium sulphate, anhyd.	1¼ oz.	30 gms.	1 oz.
Chrome alum	350 gr.	20 gms.	290 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

Immerse for 5 minutes. The film or plate is then placed, without any intermediate rinsing, in an acid hardening fixer such as G.308.

TONING BATHS

G.411

For 'Gevabrom', 'Gevatone' and 'Gevarto' papers. Prints which are to be toned should be of full contrast with clear whites and rich dark shadows. They are first bleached and then toned.

★ Bleaching

Bleach the prints in dim light in the formula given below until the deepest shadows turn to a clear yellow colour.

	B. Imp.	*Metric*	*U.S.A.*
Water (100°F. or 40°C.)	30 oz.	750 c.c.	24 oz.
Potassium ferricyanide	260 gr.	15 gms.	½ oz.
Potassium bromide	260 gr.	15 gms.	½ oz.
Water, to make	40 oz.	1,000 c.c.	32 oz.

If stored in the dark, or in a brown bottle, this solution keeps well and may be used repeatedly.

The bleached prints should then be thoroughly washed until all trace of the yellow colour has been removed. Then immerse them in the solution given below, when after a few minutes they will be completely toned.

★ Toner

	B. Imp.	*Metric*	*U.S.A.*
Sodium sulphide	260 gr.	15 gms.	½ oz.
Water, to make	40 oz.	1,000 c.c.	32 oz.

After toning, wash for 20 minutes in running water. If the tone obtained in G.411 is considered to be too yellow, this can be overcome by adding 5 c.c. of 'Vittol' solution, diluted to working strength to each 100 c.c. of sodium sulphide solution. Time required in the toner: 4–5 minutes. To produce even warmer tones add between 2 and 4 grams of potassium bromide to each litre. This must not be done until half an hour before use.

If the highlights are not completely cleared put the prints into a 10% solution of potassium metabisulphite or sodium bisulphite until the highlights are completely cleared, then wash thoroughly and dry.

★ Notes

Sodium sulphide keeps best in concentrated solution. It is therefore best to prepare a 20% stock solution for dilution as required. Too high a temperature, or too concentrated a toning bath may cause blistering of the emulsion layer. Prints that are going to be toned must be fixed and washed with scrupulous care if failures are to be avoided. Working in daylight that is too bright, or changing the composition of the toning bath, or using an exhausted bath can also cause trouble.

The unpleasant smell associated with sodium sulphide can be dispelled instantly by rinsing the dishes and containers with a dilute solution of potassium

permanganate. If after this brown spots still persist on the dishes these can readily be removed with a 5% solution of potassium metabisulphite or sodium bisulphite.

G.416

For use with all types of paper.

Blue toning with ferri-ferrocyanide (Prussian blue).

Blue-green toning by treating blue toned prints with sodium sulphide.

Prints to be toned must be thoroughly fixed and washed.

★ Blue tones

Blue toning is carried out in one step. The prints are immersed in a solution with the composition as follows:

	B. Imp.	*Metric*	*U.S.A.*
Water	4½ oz.	110 c.c.	3½ oz.
Ferric ammonium citrate (green) 5% solution	290 minims	15 c.c.	250 minims
Potassium ferricyanide 2½% solution	290 minims	15 c.c.	250 minims
Hydrochloric acid 1% solution	2½ oz.	60 c.c.	2 oz.

Toning requires only 30 seconds at 68°F. (20°C.). Prolonged immersion may cause mixed tones. The prints are then washed until the whites are clear. Toning should be carried out in weak daylight or artificial light (tungsten).

Make up the toning bath by mixing the ingredients in the order given above *immediately* before use as the solution does not keep well. Do not let the solution come into contact with metal so use porcelain, glass, vitreous enamelled steel, or plastic dishes.

★ Blue-green tones

Take prints that have been toned blue and place them in the following solution:

	B. Imp.	*Metric*	*U.S.A.*
Water	8 oz.	200 c.c.	6¾ oz.
Sodium sulphide	260 gr.	15 gms.	½ oz.
Sodium thiosulphate (hypo)	4 oz.	100 gms.	3 oz. 145 gr.

For use take 10 c.c. of stock solution and dilute with 100 c.c. of water. To this mixture add 5 c.c. of 10% hydrochloric acid. This working solution does not keep well. Carry out the toning operations in a place well away from stored sensitive photographic materials as it gives off sulphuretted hydrogen gas. After toning wash the prints for at least 15 minutes.

G.417

Particularly suitable for prints on 'Vittex' which have been developed in G.261 developer.

The browner the original tone the lighter will be the blue tone obtained.

Prints should be developed a shade lighter than is considered normal. After fixing and washing the prints are placed in the following toning bath:

★ Solution A

	B. Imp.	*Metric*	*U.S.A.*
Gold chloride	18 gr.	1 gm.	15 gr.
Calcium carbonate	55 gr.	3 gms.	45 gr.
Water, to make	10 oz.	250 c.c.	8 oz.

★ Solution B

Thiocarbamide	350 gr.	20 gms.	290 gr.
Sodium thiosulphate (hypo)	350 gr.	20 gms.	290 gr.
Potassium metabisulphite	90 gr.	5 gms.	75 gr.
Water, to make	10 oz.	250 c.c.	8 oz.

Make up these solutions 24 hours beforehand, and mix equal parts of each immediately before use. Toning takes about 5 minutes. After toning wash the prints. They can if necessary be wiped clean with a pledget of cotton wool.

G.418

For all types of paper.

Prints are first sepia toned (see G.411), washed well, and then immersed in a toner solution prepared according to the following formula. The warmer the original sepia tone the deeper the red tone will be.

★ Stock solution A

	B. Imp.	*Metric*	*U.S.A.*
Water (100°F. or 40°C.)	30 oz.	750 c.c.	24 oz.
Ammonium thiocyanate	175 gr.	10 gms.	145 gr.
Hydrochloric acid	190 minims	10 c.c.	2½ drams
Sodium chloride	175 gr.	10 gms.	145 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

★ Stock solution B

Gold chloride	18 gr.	1 gm.	15 gr.
Water, to make	4 oz.	100 c.c.	3¼ oz.

★ For use

Take 100 c.c. of A and mix in 10 c.c. of B. The colour of the print begins to change after about 10 minutes immersion. As soon as the desired tone is obtained rinse the print briefly in water and then fix the print in a 10% hypo solution. Then wash very thoroughly.

Be sure to keep the prints moving during toning so they do not stick to one another.

One litre of gold toner is sufficient to treat 40 or 50 ½-plate prints or an equivalent paper area.

G.420

Particularly recommended for prints on 'Vittex', 'Gevatone', 'Gevarto' and 'Artona'. Prints that are to be toned should be made a little darker than normal.

★ Stock solution

	B. Imp.	*Metric*	*U.S.A.*
Water 100°F. (40°C.)	40 oz.	1,000 c.c.	32 oz.
Sodium sulphide	3 oz.	75 gms.	2½ oz.
Sodium thiosulphate (hypo)	20 oz.	500 gms.	16½ oz.

★ Working solution

Water	40 oz.	1,000 c.c.	32 oz.
Stock solution	2 oz.	50 c.c.	1·6 oz.

After fixing wash the prints for about 5 minutes and then place them in the above solution until the tone required is obtained.

'Gevatone', 'Gevarto' and 'Artona'	10–20 mins.
'Vittex'	10–35 mins.

Keep prints in motion during toning.

The stock solution will keep indefinitely in well-stoppered bottles, but it is advisable to discard the working solution once it has been used.

After toning wash thoroughly for at least half an hour in running water.

REDUCERS

G.501

Suitable for over-exposed and/or over-developed negatives that are fogged or too dense.

★ Stock solution A

	B. Imp.	*Metric*	*U.S.A.*
Water (100°F. or 40°C.)	30 oz.	750 c.c.	24 oz.
Sodium thiosulphate (hypo)	4 oz.	100 gms.	3 oz. 145 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

★ Stock solution B

Potassium ferricyanide	4 oz.	100 gms.	3 oz. 145 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

For use take 100 c.c. of solution A and add 5 c.c. of solution B. If the contrast needs to be increased then increase the proportion of solution B. Use pure hypo in solution A – do not use an acid fixing bath. Stop the action slightly before it appears that the desired degree of reduction has been produced as the reducing action continues for a short while during subsequent washing. Rinse vigorously and then wash thoroughly for at least half an hour.

Solution A keeps well, solution B must be stored in a brown bottle, or out of the light. Mixed reducer solution only keeps for about an hour.

G.502

For use on over-developed negatives.

Permanganate reducer does not act so energetically as reducers G.503 and G.504 but it has the advantage that it can be used repeatedly.

★ Stock solution A

	B. Imp.	*Metric*	*U.S.A.*
Potassium permanganate	70 gr.	4 gms.	60 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

★ Stock solution B

Sulphuric acid	40 minims	2 c.c.	½ dram
Water, to make	40 oz.	1,000 c.c.	32 oz.

Both solutions keep well. For use take 100 c.c. water, add 15 c.c. of solution A, then 15 c.c. of solution B. After reduction fix for several minutes in an acid fixing bath and then wash thoroughly.

G.503

Reducer for very hard negatives such as over-developed and over-exposed negatives. This reducer attacks the heavier densities – highlights – first (super-proportional).

	B. Imp.	*Metric*	*U.S.A.*
Ammonium persulphate	1½ oz.	40 gms.	1 oz. 145 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

The solution must be used immediately after it has been prepared, as it soon loses its activity. It is not suitable for negatives which have been developed in paramidophenol (Amidol).

To arrest the action of this reducer immerse the negative for half a minute in a 10% solution of sodium sulphite. Then wash for 15–20 minutes.

G.504

Reducer for very hard negatives such as over-developed and over-exposed negatives.

This reducer attacks the highlights first (darker areas). It gives more predictable results than bath G.503.

	B. Imp.	*Metric*	*U.S.A.*
Ammonium persulphate	350 gr.	20 gms.	290 gr.
Sulphuric acid, concentrated	11 drops	10 drops	9 drops
Water, to make	40 oz.	1,000 c.c.	32 oz.

Use distilled water if available and add 1·5 c.c. of a 1% of common salt per 100 c.c. of water. The reducer solution does not keep and must be made up immediately before use.

Remove the negative from the reducer before the desired degree of reduction has been achieved and immerse the negative in a plain hypo bath for 5 minutes. Then wash thoroughly.

INTENSIFIERS

G.526

For use with under-exposed negatives, or in cases of under-development even of over-exposed negatives.

	B. Imp.	*Metric*	*U.S.A.*
Water (100°F. or 40°C.)	30 oz.	750 c.c.	24 oz.
Mercuric chloride (Poison)	350 gr.	20 gms.	290 gr.
Hydrochloric acid (concentrated)	80 minims	3 c.c.	1 dram
Potassium bromide	350 gr.	20 gms.	290 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

Dissolve the mercuric chloride in warm water and allow to cool, but do not stir or shake the container before use. The solution will keep well in a dark brown bottle. Put the negative emulsion up into the solution and allow the silver image to bleach. The more vigorous this reaction the contrastier the resulting negative. The negative is completely bleached when it is completely white when viewed through the back.

If only the shadows are to be intensified (i.e. in cases of *under*-exposure) immerse the dry negative shadows to be bleached (removing it before the heavier densities are affected).

As soon as the negative is sufficiently bleached wash it for 10 minutes in running water. Any slight deposit that occurs can be removed by carefully swabbing the surface under water with a piece of cotton wool.

The negative is then blackened in the following solution:

	B. Imp.	*Metric*	*U.S.A.*
Ammonium hydroxide (0·910)	1 fl. oz.	25 c.c.	6 drams
Water, to make	40 oz.	1,000 c.c.	32 oz.

Finally wash for 10 minutes.

For negatives that it is desired to preserve it is better not to use ammonia, but to blacken in a 10% solution of sodium sulphite, or in an ordinary developer.

★ Note

In warm weather be careful to avoid differences in temperature between the processing solutions and the wash water, as this can cause the gelatine layer to reticulate. Too prolonged immersion in the intensifier solution, or too great a degree of intensification can likewise result in this trouble. To prevent reticulation put the negative through a hardening bath such as G.354 before intensification. Do not intensify negatives until they have been properly washed and be careful not to touch the emulsion layer with the fingers or to clean all finger marks off with carbon tetrachloride or 'Thawpit'. Fingerprints show up very clearly during intensification.

G.527

For very weak negatives, free of fog or veil.

★ Stock solution A

	B. Imp.	*Metric*	*U.S.A.*
Uranium nitrate (Poison)	175 gr.	10 gms.	145 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

★ Stock solution B

Potassium ferricyanide	175 gr.	10 gms.	145 gr.
Water, to make	40 oz.	1,000 c.c.	32 oz.

A few minutes before use mix 5 parts of A with 5 parts of B. Shake the mixture and then add 1 part of glacial acetic acid or 4 parts of 28% acetic acid. The negative will turn a reddish brown colour in this solution, the redder the tone the greater being the intensification.

Stop the action at the stage desired and wash until all the yellow coloration has been removed from the clear areas. Washing should not be unduly prolonged.

If the intensification has been carried too far a few drops of ammonia or sodium carbonate may be added to the wash water.

USEFUL HINTS AND RECIPES

FOR THE DARKROOM

Cleaning dishes

1. Rinse with dilute hydrochloric acid. 1 part to 20 parts. Then wash in water.
2. Stubborn deposits can be removed with the following solution:

Water	1,000 c.c. (1 litre)
Pot. bichromate	60 gm.
Sulphuric acid (concentrated)*	60 c.c.

After treatment wash with a vigorous flow of water then put aside to dry. Be careful in using this dish cleaning solution as it attacks the skin.

* Warning

Never add water to the concentrated acid, always add the sulphuric acid to the water, pouring it in a thin stream down the side of the container, stirring vigorously all the time.

Cleaner for stained fingers

(*a*) You can avoid staining your fingers brown in developers and fixers by rinsing your fingers thoroughly each time they come into contact with the solutions.

(*b*) Brown stained fingers can be cleaned with:

1. Fresh lemon juice; or
2. Water — 1,000 c.c. (1 litre)
 Pot. permanganate — 2 gm.
 Sulphuric acid — 10 c.c.

After immersion in this bath, which will stain the skin brown itself, rinse the fingers in an acid fixing bath (or in a solution of potassium metabisulphite) and finally wash thoroughly with soap and water.

Hard water

It is strongly recommended to avoid using very hard water to make up photographic processing solutions.

To remove the bulk of the dissolved salts, boil the water and allow it to stand to cool overnight, then decant it carefully. Boiling drives off the dissolved gases and precipitates undesirable organic material as well.

Instead of boiling the water the calcium salts can be precipitated by adding 5 gm. of sodium carbonate to each litre of water and allowing it to stand, decanting the clear water the next day or filtering off the precipitated chalk.

When is the fixer exhausted?

The fixing bath has the job of removing the silver chloride, bromide and iodide that has not been exposed and developed to silver. A given amount of fixer does not dissolve equal amounts of these three silver salts. Silver iodide for instance is much less soluble and therefore saturates a disproportionate amount of hypo: highly sensitive emulsions which contain relatively large amounts of iodide (up to 60%) will therefore exhaust fixing baths rather more rapidly than say papers or lantern plates.

How can we tell when a bath is used up? The rule of thumb method is to fix a piece of film in a fresh bath, and a similar piece in the solution in question. If the used solution takes more than twice as long to clear the film as a fresh bath then it is nearing exhaustion. There is, however, a more positive test which can tell whether a bath is exhausted quite simply. Put a small quantity of the fixer into a glass container such as a test tube, or a drinking glass will do, so that it can be seen, and then allow a few drops of a 10% potassium iodide solution to drop into it. If the potassium iodide does not dissolve in the fixer but gives a yellow precipitate then this is a sure sign that the hypo in the fixing solution is saturated with silver salts. If the precipitate redissolves on shaking up the glass then it follows that the bath is very nearly exhausted. In either case it is better renewed.

This simple positive method should be used from time to time so that some idea can gradually be obtained of how often it is necessary to renew the fixing bath.

Fix negatives separately from papers

Unexposed and undeveloped silver salts are dissolved away and removed from the emulsion by the action of the sodium thiosulphate. For it to be effective then the fixer must always have present an excess of active sodium thiosulphate. Any given quantity of fixer can however only dissolve a fixed amount of the silver halides (silver bromide, iodide and chloride). 100 c.c. of a 20% hypo solution will dissolve 6 gm. of silver bromide and only 0·6 gm. of silver iodide. Modern high speed negative emulsions which are relatively rich in iodide therefore exhaust the fixer more rapidly than do papers. For economical working therefore it is better to have two separate fixing baths for negative and positive materials. At the same time this will prevent the accumulation of silver iodide in the bath causing any undesirable change of tone in print images.

Sterilization of wash water

Sometimes after washing plates and films are found to be spoiled by small round hollow spots which make them quite unusable. These spots have a small central dark nucleus surrounded by a white halo. This curious defect, which occurs most often during the warmer months, is caused by unfiltered cloudy wash water which contains micro-organisms. Bacteria are left in the gelatine layer which they soon attack strongly. They set about their destructive work during the slow course of drying and sometimes the emulsion is covered with hundreds of small spots. This can be avoided by using clean filtered water.

To be quite safe a disinfectant should be added to it. To each litre of wash water add 3 c.c. (or 3 gm.) of a 5% solution of carbolic acid (phenol). Caution: concentrated carbolic acid is dangerous.

Wash water sterilized in this way will completely prevent this type of defect.

After washing it is advisable to place films and plates to dry in a current of air, not too close to one another as this retards drying.

It is of great importance to dry quickly to forestall bacterial attack.

Removing water from alcohol

1. Place several sheets of dry gelatine in the stock solution and remove them after a short while. After drying the gelatine sheets can be re-used.

2. Better still. Heat a little copper sulphate until it is a white powder, then add it to the alcohol and water. Remove the copper sulphate as soon as it has reacquired its blue colour.

Testing after washing

To make sure that prints (or films) have been properly washed, i.e. that all the hypo has been removed, drain off a print into a beaker or glass and allow one or two drops of a 1% potassium permanganate solution to fall into the water. If this retains the violet colour then washing has been adequate. If after 5 minutes the colour turns a dirty brown, due to the remaining hypo, washing should be continued.

Paper sticking to a negative

Place the negative and paper in water and separate them carefully. Then place the film or plate in alcohol and then in a mixture of equal parts of ether and alcohol. Small adherent patches will come loose in this mixture and can be rubbed gently with a piece of cotton wool. Then rinse the negative and refix in a 10% hypo solution and finally wash thoroughly and put to dry.

Dust on negatives

1. Remove the dust gently with a soft brush* or better:
2. Rub an ebonite rod with a silk or nylon handerchief to charge it with static electricity and pass it carefully over the negative, close to it without touching, when it will attract all the dust.

* Too vigorous polishing glass or film base merely charges the surface and attracts more dust. Anti-static paste can be bought which, rubbed on gently, will discharge the surface which can then be blown clear. Alternatively a brush carrying a pellet of a weak radioactive substance may be used to discharge the surface and release the dust.

FORMULAE FOR RETOUCHING

Retouching varnish

Turpentine (refined)	75 c.c.
Gum dammar	10 gm.

Shake up the dammar in a flask with the turpentine. This formula is very satisfactory.

Another mixture which can be used:

Turpentine (refined)	50 c.c.
Benzine	50 c.c.
Oil of lavender	5 c.c.
Gum dammar	10 gm.

If the solution is too thick it may readily be thinned with turpentine.

For use apply one of these two solutions to the area to be retouched and spread it evenly with a pad of soft fluffless cloth.

Wax polish

Benzine	100 c.c.
Beeswax	1 gm.

After dissolving the wax, filter the solution. For use pour solution over the whole negative area. It dries rapidly.

This protective layer has the advantage that no cloth is needed to apply it. Also if the amount of pencil retouching is subsequently found to be insufficient additional pencil work can be carried out on the negative without affecting the work that has already been done.

Matt varnish

A good matt varnish is not easy to make up and may not be entirely satisfactory in spite of the most stringent precautions.

The commercial variety which is ready mixed for use is therefore advised.

It is usually supplied in three colours, clear, yellow and red. A good formula for its preparation is as follows:

Ether	100 c.c.
Gum sandarac	8 gm.
Gum dammar	3 gm.

When these are completely dissolved filter through a coarse filter paper as quickly as possible and add:

Benzol	40 c.c.
Alcohol	10 drops

It may take several days for the gums to be digested as they dissolve very slowly. The process can be speeded up considerably by grinding the gum into a fine powder in a pestle and mortar.

Negative varnish (for use warm)

This is used to protect the negative from the effects of atmospheric moisture and abrasion marks. The plate should first be warmed and a varnish made to the formula given below, then poured on:

Alcohol (pure)	600 c.c.
Gum sandarac	40 gm.
Castor oil	90 cc.

When the gum sandarac has dissolved, filter through a coarse Whatman filter paper.

This varnish is also suitable as a 'tooth' for retouching.

Cold varnish (benzol based)

It is not necessary to warm the plate before applying the following varnish which is quite easily made up:

Alcohol	10 c.c.
Gum dammar	8 gm.
Benzol	90 c.c.

Grind the dammar gum first in a mortar, then add the alcohol to it. When completely dissolved add the benzol. Filter and the solution is ready for use.

Celluloid varnish (highly inflammable)

Acetone	125 c.c.
Amyl acetate	125 c.c.
Cellulose nitrate (celluloid)	8 gm.

Do not use cellulose acetate (safety base) instead of the nitrate.

This varnish can be diluted if required with acetone. To reduce the gloss increase the proportion of amyl acetate.

Fixing pencil or crayon retouching

Prints that have been extensively retouched with pencil should be 'fixed' to ensure the retouching lasts. To do this hold the print about 12 in. away from and in the stream jet of a kettle kept gently on the boil, keeping it on the move, until it becomes slightly damp. Then put it to cool between two sheets of glass.

Copying broken negatives

Take a clean piece of glass the same size as the plate, rest the broken pieces on it glass down and stick them together with Canada balsam, making the parts match as closely as possible.

Then fasten down the pieces to the glass plate with adhesive tape and put aside for 24 hours to dry.

In printing such a negative keep the contact frame in continuous movement during the exposure (in all directions, up and down, from side to side) so that the join does not cast a shadow on the paper.

Removing the gelatine layer (after L. P. Clerc)

★ 1. Discarded negatives

Immerse the negative in warm water until the gelatine comes loose, when it can be brushed off. (If it is stubborn use a dilute solution of sodium carbonate, or other alkali, or of sodium hypochlorite, which can be obtained readily as a commercial bleach.)

★ 2. A good negative

The glass only being broken. (Stripping and transferring the emulsion layer to a new support.)

Score the edge of the plate lightly with a knife and then immerse it for at least half an hour in the following solution (which can be used repeatedly).

Sodium carbonate (anhydr.)	30–40 gm.
Formalin	50 c.c.
Glycerine	10 c.c.
Water to make	1,000 c.c. (1 litre)

On taking it from the bath the surface of the negative is blotted off and left to dry. Drying can be speeded up by gentle heat.

The dry negative is then placed in a weak hydrochloric acid, about 5%, so that a weak effervescence is generated. Some of the carbon dioxide is generated between the gelatine layer and the glass and separates them at least sufficiently to allow it to be transferred to paper.

The paper (transfer) sheet, which is larger than the negative, is placed to soak in water. The transfer is carried out in the following manner: the negative is placed flat on the bench and the sheet of paper is placed on top of it and excess water removed and the pair squeegeed into contact with a rubber roller squeegee worked from the centre outwards.

Finally the paper sheet is lifted carefully at one corner until a corner of the negative shows. If the negative has not stuck to the paper it should be lifted with the blade of a knife until it sticks to the paper. Then holding negative and paper between finger and thumb pull both together with an even regular tension. The film, when it has been detached, can then be transferred to a permanent support.

If the negative film is to be placed on glass or film this must be prepared beforehand with an adhesive layer, a weak solution of gum arabic or a 10% gelatine solution which is applied warm and allowed to set (before the negative emulsion layer is transferred to it).

The film can also be transferred to a piece of perfectly clean glass which has been polished with french chalk or coated with wax dissolved in ether. After it has been allowed to dry on the temporary support it should be reinforced by coating with a layer of rubber latex solution which when dry is then coated with a layer of collodion or celluloid varnish (see previous page).

Either before or after it has been laid down on the permanent support the gelatine film should be washed in water to remove traces of the chemicals used in stripping. If washing is carried out before transfer then place a piece of clear glass larger than the negative at the bottom of the tray so that the negative can be lifted from the tray without any danger of tearing.

Be careful to see that the negative is transferred to the support so it is the desired way round. The position left to right will differ according to whether it is on a temporary or final support and whether it is to be used to make prints that are the correct way round or laterally reversed. If when the negative layer has been stripped on to the paper, the outside surface is not the one which it is desired to place face down on the final support, then it can be transferred to a second sheet of paper before it is finally transferred to the permanent support.

MISCELLANEOUS

Protective coating for emulsion layers

Large (exhibition) prints on rough or textured papers can be protected from damage, dust and atmospheric action by rubbing over the surface a layer of wax polish or a fixative. This treatment also gives the shadows a richer tone and depth although it unfortunately also imparts a gloss to the surface.

To make paper negatives more transparent

Paper base can be rendered translucent by treating with the following mixture:

Camphorated oil	8 c.c.
Alcohol (methylated spirit will do)	4 c.c.
Paraffin	1 c.c.

This preparation is applied to the back of the paper with a piece of cotton wool. It will dry rapidly and most of the paper texture will disappear.

Drying-marks and bacteria spots

This defect which often mars negatives can be prevented by using a hardening fixing bath or a hardening bath after fixation (see formulae pp. 374 et seq.) (or by rinsing in distilled water containing wetting agent 'Gevatol' before putting to dry, see p. 381).

Marks can generally be removed either by:

1. Washing well and drying in a warm dry location or, better,
2. Rinsing in water then immersing in the following solution:

Water	100 parts
Formalin (40% formaldehyde)	10 parts

Then drying in a warm dry place.

To remove greasy marks from prints

Mix starch with a small amount of benzene until a hard dry 'nut' is obtained. Rub the grease spot with this 'nut' until it disappears. Do not use a paste as this will leave a ring mark as will benzene used alone.

Removing inks spots from prints

(May not be effective with some modern inks.)

1. Make up the following solution:

Water	500 c.c.
Pot. permanganate	1 gm.
Hydrochloric acid (concentrated)	5 c.c.

When immersed in this bath the print will bleach, but the ink spot will be intensified. Treat the print next in a 5% solution of potassium metabisulphite then redevelop the print. After this treatment the ink will have disappeared.

2. Better still:

Prepare a 10% solution of oxalic acid. Moisten the ink spots in bright daylight with this solution, using a pledget of cotton wool. When they have been removed wash the print thoroughly.

Titles on post cards

It is best not to write on the negatives themselves because this might spoil them for subsequent use. To produce white lettering (on a dark ground) write the title by hand, or have it printed on a thin piece of cellophane, fixed out film, or pressure sensitive cellulose tape. This strip can then be fastened to the negative taking care that it is reversed like the negative. The ink or paint used must be opaque. To increase the density of the writing it is advisable to dust it while wet with powdered bitumen.

If black lettering on a white ground is required it is best to have this printed by letterpress.

Reviving leather and fabric bellows

It is only to be expected that after many months or years of use the leather bellows of a camera should lose their original freshness and show signs of wear.

To prevent this rub over the leather occasionally with a soft cloth moistened with the following mixture:

Lanoline	50 parts
Castor oil	40 parts
Sod. stearate	5 parts
Japanese wax	5 parts

WARNING

* Poisons

Quite a number of chemicals used in photography are poisonous, e.g.:

Acetic acid (especially glacial acetic acid) – hydrochloric acid – nitric acid – sulphuric acid – methyl alcohol – potassium alum – ammonia – ferric chloride – all the bichromates – potassium ferricyanide – formalin – urea nitrate – the oxalates – pyrogallol – silver salts (e.g. silver nitrate) – cyanides (e.g. potassium cyanide) – lead salts (e.g. lead acetate, lead nitrate) – mercury salts – copper sulphate – zinc salts.

* Corrosive and caustic substances

The following chemicals attack the skin and burn clothes and the mouth and stomach: acetic acid (especially glacial acetic acid) – hydrochloric acid – nitric acid – sulphuric acid – ammonia – ferric chloride – formalin – silver nitrate – caustic soda – caustic potash (potassium hydrate).

* Volatile chemicals

The following chemicals evaporate rapidly: acetone – alcohol – ammonia – benzene – ether – formalin.

* Hygroscopic chemicals

The following substances absorb water (from the atmosphere): glacial acetic acid – citric acid – concentrated sulphuric acid – alcohol – potassium carbonate – calcium chloride – gold chloride – ferric chloride – sodium sulphide – urea nitrate – caustic potash – the thiocyanates – caustic soda.

* Efflorescent chemicals

These lose their water of crystallization to the air: oxalic acid – sodium carbonate – copper sulphate – ferrous sulphate.

* To be protected from strong light

The following substances must be stored out of direct sunlight (e.g. in dark brown bottles): potassium ferricyanide – potassium permanganate – solutions of gold salts – mercury salts – all developer solutions, fixing-toning solutions and toning solutions.

* Inflammable (or very combustible)

Acetone – alcohol – ether – nitrate film base (*not* acetate 'safety' base) – flash powder.

* Easily oxidized

All developing agents.

* Alum

Alum without any qualification is the double salt of potassium and aluminium. There is also chrome alum.

* Potassium Ferri- and Ferrocyanide

Do not get confused between these two chemicals: ferr*i*cyanide is dark red-orange crystals and ferr*o*cyanide is yellow and they have very different properties.

* Iron and its compounds

Do not mistake:

Ferrous sulphate for ferric sulphate.
Ferrous oxcalate for ferric oxalate.
Iron sulphate (so called) is always ferr*ous* sulphate whereas
Iron persulphate is always ferr*ic* sulphate.

* Vitriol

Vitriol, without qualification, is sulphuric acid – also called oil of vitriol.
White vitriol is zinc sulphate.
Blue vitriol is copper sulphate.
Green vitriol is ferrous sulphate.

Pharmacists and dry salters have many quaint old-fashioned names for chemicals, especially the more common acids and metallic salts and aromatics. It is wise not to ask for or accept packages labelled in this way but always to use the correct chemical name and to have this on the label.

Poisons should be kept in a locked cupboard, and all chemicals, especially dangerous ones, kept on shelves where it is *impossible* for children, however daring, to reach them. Fatal accidents due to carelessness are everyday occurrences, and you should not take any risks.

PART SIX

APPENDICES

I. Various Useful Tables
II. Sensitometry
III. Photographic Effects
IV. Book List
V. Index

I. VARIOUS USEFUL TABLES

Table A: Angle of view for lenses of focal lengths from 3.5 to 80 cm. when used on normal negative sizes

Focal length cm	Negative size and diagonal in cm														
	2.4 × 3.6 4.33	4.5 × 6 7.5	6 × 6 8.5	6.5 × 9 11	9 × 12 15	10 × 15 18	12 × 16 20	13 × 18 22	18 × 24 30	24 × 30 38.4	24 × 36 43.3	30 × 40 50	40 × 50 64	50 × 60 78	70 × 80 106
3.5	63°	93°	103°	115°	—	—	—	—	—	—	—	—	—	—	—
5	47°	74°	81°	95°	112°	—	—	—	—	—	—	—	—	—	—
7.5	32°	53°	59°	73°	90°	100°	106°	112°	—	—	—	—	—	—	—
9	27°	45°	51°	63°	80°	90°	96°	101°	118°	—	—	—	—	—	—
10	24°	41°	46°	58°	74°	84°	90°	96°	113°	—	—	—	—	—	—
12	20°	34°	39°	49°	64°	74°	80°	86°	103°	116°	—	—	—	—	—
13.5	—	31°	35°	44°	58°	67°	73°	79°	96°	110°	116°	—	—	—	—
15	—	28°	32°	40°	53°	62°	67°	73°	90°	104°	110°	118°	—	—	—
16.5	—	25°	29°	37°	49°	57°	62°	68°	85°	99°	105°	113°	—	—	—
18	—	24°	26°	34°	45°	53°	58°	63°	80°	94°	101°	109°	—	—	—
21	—	20°	23°	29°	39°	46°	51°	56°	71°	85°	92°	100°	120°	—	—
24	—	—	20°	26°	35°	41°	45°	49°	64°	74°	84°	92°	106°	117°	—
27	—	—	—	23°	31°	37°	41°	44°	58°	71°	77°	86°	100°	111°	—
30	—	—	—	21°	28°	33°	37°	40°	53°	65°	72°	80°	94°	105°	—
36	—	—	—	—	24°	28°	31°	34°	45°	56°	62°	69°	83°	95°	112°
42	—	—	—	—	20°	24°	27°	29°	39°	49°	54°	62°	75°	86°	103°
48	—	—	—	—	—	21°	24°	26°	35°	44°	48°	55°	67°	79°	97°
60	—	—	—	—	—	—	—	21°	28°	35°	40°	45°	56°	66°	88°
70	—	—	—	—	—	—	—	—	24°	31°	34°	39°	49°	58°	74°
80	—	—	—	—	—	—	—	—	21°	27°	28°	35°	44°	52°	67°

Table B: Depth of Field Chart (see pp. 29 *et seq.*)

In metres:

Ta \ Tv	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	1.3	1.5	1.6	1.7	1.7	1.7	1.8	1.8	1.8	1.8	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
2	1.3	2	2.4	2.7	3	3	3	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.5	3.6	3.6	3.6	3.6	3.6
3	1.5	2.4	3	3.4	3.7	4	4.2	4.4	4.5	4.6	4.7	4.8	4.9	5	5	5	5.1	5.1	5.1	5.2
4	1.6	2.7	3.4	4	4.4	4.7	5	5.3	5.5	5.7	5.9	5.9	6	6.2	6.3	6.3	6.4	6.5	6.6	6.7
5	1.7	3	3.7	4.4	5	5.5	5.8	6.1	6.4	6.7	6.9	7.1	7.2	7.4	7.5	7.6	7.7	7.8	7.9	8
6	1.7	3	4	4.7	5.5	6	6.5	6.8	7.2	7.5	7.8	8	8.2	8.4	8.6	8.8	8.9	9	9.1	9.2
7	1.7	3	4.2	5	5.8	6.5	7	7.5	7.9	8.2	8.5	8.8	9	9.3	9.6	9.8	9.9	10	10	10
8	1.8	3.2	4.4	5.3	6.1	6.8	7.5	8	8.5	8.9	9.3	9.6	9.8	10	10	11	11	11	11	11
9	1.8	3.3	4.5	5.5	6.4	7.2	7.9	8.5	9	9.5	9.9	10	10.5	11	11	11.5	11.5	12	12	12
10	1.8	3.3	4.6	5.7	6.7	7.5	8.2	8.9	9.5	10	10.5	11	11	11.5	11.5	12	12.5	13	13	13.5
11	1.8	3.4	4.7	5.9	6.9	7.8	8.5	9.3	9.9	10.5	11	11.5	12	12.5	12.5	13	13	13.5	13.5	14
12	1.8	3.4	4.8	5.9	7.1	8	8.8	9.6	10	11	11.5	12	12.5	13	13	13.5	14	14.5	14.5	15
13	1.9	3.5	4.9	6	7.2	8.2	9	9.8	10.5	11	12	12.5	13	13.5	14	14.5	14.5	15	15.5	15.5
14	1.9	3.5	5	6.2	7.4	8.4	9.3	10	11	11.5	12.5	13	13.5	14	14.5	15	15	15.5	16	16.5
15	1.9	3.5	5	6.3	7.5	8.6	9.6	10	11	11.5	12.5	13	14	14.5	15	15.5	16	16	16.5	17
16	1.9	3.6	5	6.3	7.6	8.8	9.8	11	11.5	12	13	13.5	14.5	15	15.5	16	16.5	17	17.5	18
17	1.9	3.6	5.1	6.4	7.7	8.9	9.9	11	11.5	12.5	13	14	14.5	15	16	16.5	17	17.5	18	18
18	1.9	3.6	5.1	6.5	7.8	9	10	11	12	13	13.5	14.5	15	15.5	16	17	17.5	18	18.5	19
19	1.9	3.6	5.1	6.6	7.9	9.1	10	11	12	13	13.5	14.5	15.5	16	16.5	17.5	18	18.5	19	19.5
20	1.9	3.6	5.2	6.7	8	9.2	10	11	12	13.5	14	15	15.5	16.5	17	18	18	19	19.5	20

T_v=Distance of nearest sharp point. T_a=Distance of furthest sharp point.

In feet:

Ta \ Tv	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	25	30	35	40	45	50	100
1	1-0	1-4	1-6	1-7	1-8	1-9	1-9	1-9	1-10	1-10	1-10	1-10	1-11	1-11	1-11	1-11	1-11	1-11	1-11	1-11	2-0	2-0
2	1-4	2-0	2-5	2-8	2-10	3-0	3-1	3-2	3-3	3-4	3-5	3-6	3-7	3-8	3-8	3-8	3-9	3-9	3-10	3-10	3-10	3-11
3	1-6	2-5	3-0	3-5	3-9	4-0	4-2	4-4	4-6	4-7	4-10	5-0	5-1	5-2	5-3	5-4	5-5	5-6	5-7	5-7	5-8	5-10
4	1-7	2-8	3-5	4-0	4-5	4-10	5-1	5-4	5-6	5-9	6-0	6-3	6-5	6-6	6-8	6-10	7-0	7-2	7-3	7-5	7-6	7-8
5	1-8	2-10	3-9	4-5	5-0	5-5	5-10	6-2	6-5	6-8	7-1	7-4	7-7	7-10	8-0	8-4	8-7	8-9	8-11	9-0	9-1	9-6
6	1-9	3-0	4-0	4-10	5-5	6-0	6-6	6-10	7-2	7-6	8-0	8-5	8-9	9-0	9-3	9-8	10-0	10-3	10-5	10-7	10-8	11-4
7	1-9	3-1	4-2	5-1	5-10	6-6	7-0	7-6	7-11	8-3	8-10	9-4	9-9	10-1	10-4	10-11	11-4	11-8	11-11	12-1	12-3	13-1
8	1-9	3-2	4-4	5-4	6-2	6-10	7-6	8-0	8-6	8-11	9-7	10-2	10-8	11-1	11-5	12-1	12-8	13-0	13-4	13-7	13-9	14-10
9	1-10	3-3	4-6	5-6	6-5	7-2	7-11	8-6	9-0	9-6	10-4	10-11	11-6	12-0	12-5	13-2	13-10	14-4	14-8	15-0	15-3	15-6
10	1-10	3-4	4-7	5-9	6-8	7-6	8-3	8-11	9-6	10-0	10-11	11-8	12-4	12-10	13-4	14-3	15-0	15-6	16-0	16-4	16-8	18-1
12	1-10	3-5	4-10	6-0	7-1	8-0	8-10	9-7	10-4	10-11	12-0	12-11	13-8	14-5	15-0	16-2	17-1	17-10	18-5	19-0	19-5	21-6
14	1-10	3-6	5-0	6-3	7-4	8-5	9-4	10-2	10-11	11-8	12-11	14-0	15-0	15-8	16-6	17-11	19-0	20-0	20-8	21-4	21-11	24-6
16	1-11	3-7	5-1	6-5	7-7	8-9	9-9	10-8	11-6	12-4	13-8	15-0	16-0	16-10	17-9	19-6	20-10	22-0	22-11	23-7	24-3	27-6
18	1-11	3-8	5-2	6-6	7-10	9-0	10-1	11-1	12-0	12-10	14-5	15-10	16-10	18-0	18-11	20-10	22-6	23-10	24-11	25-8	26-5	30-6
20	1-11	3-8	5-3	6-8	8-0	9-3	10-4	11-5	12-5	13-4	15-0	16-6	17-9	18-11	20-0	22-2	24-0	25-6	26-8	27-8	28-7	33-4
25	1-11	3-8	5-4	6-11	8-4	9-8	10-11	12-1	13-2	14-3	16-2	17-11	19-6	20-10	22-2	25-0	27-4	29-2	30-10	32-0	33-4	40-0
30	1-11	3-9	5-5	7-0	8-7	10-0	11-4	12-8	13-10	15-0	17-1	19-0	20-10	22-6	24-0	27-4	30-0	32-4	34-4	36-0	37-6	40-6
35	1-11	3-9	5-6	7-2	8-9	10-3	11-8	13-0	14-4	15-6	17-10	20-0	22-0	23-10	25-6	29-2	32-4	35-0	37-5	39-5	41-3	52-0
40	1-11	3-10	5-7	7-3	8-11	10-5	11-11	13-4	14-8	16-0	18-5	20-8	22-11	24-11	26-8	30-10	34-4	37-5	40-0	42-5	44-6	57-0
45	1-11	3-10	5-7	7-5	9-0	10-7	12-1	13-7	15-0	16-4	19-0	21-4	23-7	25-8	27-8	32-0	36-0	39-5	42-5	45-0	47-6	62-0
50	2-0	3-10	5-8	7-6	9-1	10-8	12-3	13-9	15-3	16-8	19-5	21-11	24-3	26-5	28-7	33-4	37-6	41-3	44-6	47-6	50-0	66-8
100	2-0	3-11	5-10	7-8	9-6	11-4	13-1	14-10	16-6	18-1	21-6	24-6	27-6	30-6	33-4	40-0	46-0	52-0	57-0	62-0	66-8	100

The values in the table show the distance in both metres and in feet on which the lens should be focused, or to which the focusing scale should be set, in order to embrace any pair of values of T_v and T_a.

Table C: Table showing the relation between various systems of marking lens apertures

Stop Ratio F/No.	*Zeiss-Rudolph*	*Dallmeyer*	*'Universal' (British-U.S.)*	*Stolze*
f/3·2	256			1
f/3·5	192			1·5
f/4			1	
f/4·5	128			2
f/5·5		3		3
f/5·6			2	
f/6·3	64			4
f/7			3	
f/7·2				5
f/7·7		6		6
f/8			4	
f/9	32		5	8
f/9·5		9		12
f/9·8			6	
f/11		12		
f/11·3			8	
f/12·5	16		10	16
f/13·9			12	
f/15·5		24		24
f/16			16	
f/18	8			32
f/19·5			24	
f/21·9		48		
f/22				48
f/22·6			32	
f/25	4			64
f/28			48	
f/31				96
f/32			64	
f/36	2			128
f/39			96	
f/43·8		192		
f/44				192
f/45·2			128	
f/50	1			256
f/62		384		
f/64			256	

Table D: Relative exposure times required for enlargement to various sizes

Multiply exposure by	Enlargement ratio									
	1	**1 1/2**	**2**	**2 1/2**	**3**	**4**	**5**	**6**	**8**	**10**
	1	1 1/2	2 1/4	3	4	6	9	12	20	30
	2/3	**1**	1 1/2	2	2 3/4	4	6	8	13	20
	1/2	3/4	**1**	1 1/4	1 3/4	2 3/4	4	5 1/2	9	13
	1/3	1/2	3/4	**1**	1 1/4	2	3	4	6 3/4	10
	1/4	1/3	1/2	3/4	**1**	1 1/2	2 1/4	3	5	7 1/2
	1/6	1/4	1/3	1/2	2/3	**1**	1 1/2	2	3 1/2	5
	1/9	1/6	1/4	1/3	1/2	2/3	**1**	1 1/3	2 1/4	3 1/4
	1/12	1/8	1/5	1/4	1/3	1/2	3/4	**1**	1 3/4	2 1/2
	1/20	1/13	1/9	1/6	1/5	1/3	1/2	3/5	**1**	1 1/2
	1/30	1/20	1/13	1/10	1/7	1/5	1/3	3/5	2/3	**1**

Example

The correct time for a 2x enlargement, as established by test strips, is found to be 8 seconds. What exposure time will be required for a 5x enlargement at the same stop.

Answer

Find 2x on the top line of the above table, move down vertically until the figure 1 is reached, now move horizontally until you are directly beneath the 5x figure. This reads 4. The exposure for a 2x magnification should therefore be multiplied by 4 and is therefore $8 \times 4 = 32$ seconds.

Table E: Temperature: Corresponding values of Centigrade and Fahrenheit scales

C	F	C	F	C	F
−30	−22·0	14	57·2	58	136·4
−29	−20·2	15	59·0	59	138·2
−28	−18·4	16	60·8	60	140·0
−27	−16·6	17	62·6	61	141·8
−26	−14·8	18	64·4	62	143·6
−25	−13·0	19	66·2	63	145·4
−24	−11·2	20	68·0	64	147·2
−23	− 9·4	21	69·8	65	149·0
−22	− 7·6	22	71·6	66	150·8
−21	− 5·8	23	73·4	67	152·6
−20	− 4·0	24	75·2	68	154·4
−19	− 2·2	25	77·0	69	156·2
−18	− 0·4	26	78·8	70	158·0
−17	1·4	27	80·6	71	159·8
−16	3·2	28	82·4	72	161·6
−15	5·0	29	84·2	73	163·4
−14	6·8	30	86·0	74	165·2
−13	8·6	31	87·8	75	167·0
−12	10·4	32	89·6	76	168·8
−11	12·2	33	91·4	77	170·6
−10	14·0	34	93·2	78	172·4
− 9	15·8	35	95·0	79	174·2
− 8	17·6	36	96·8	80	176·0
− 7	19·4	37	98·6	81	177·8
− 6	21·2	38	100·4	82	179·6
− 5	23·0	39	102·2	83	181·4
− 4	24·8	40	104·0	84	183·2
− 3	26·6	41	105·8	85	185·0
− 2	28·4	42	107·6	86	186·8
− 1	30·2	43	109·4	87	186·6
0	32·0	44	111·2	88	190·4
1	33·8	45	113·0	89	192·2
2	35·6	46	114·8	90	194·0
3	37·4	47	116·6	91	195·8
4	39·2	48	118·4	92	197·6
5	41·0	49	120·2	93	199·4
6	42·8	50	122·0	94	201·2
7	44·6	51	123·8	95	203·0
8	46·4	52	125·6	96	204·8
9	48·2	53	127·4	97	206·6
10	50·0	54	129·2	98	208·4
11	51·8	55	131·0	99	210·2
12	53·6	56	132·8	100	212·0
13	55·4	57	134·6		

Table F: Conversion tables

A. Length

1 fathom	2 yards	1·83 metres
1 yard	3 feet	0·915 ,,
1 foot	12 inches	0·305 ,,
1 inch		0·0254 ,,

B. Weight

1 pound (lb.)	16 ounces (oz.)	0·453 kg.
1 oz.	437½ grains (gr.)	28·350 g.
1 gr.		0·065 g.

C. Volume – B. Imp.

1 gallon	4 quarts	4·5 litres		
1 quart	2 pints	1·13 ,,		
1 pint	4 gills	0·56 ,,		
1 gill	5 fluid ounces	0·14 ,,	or 140	cc.
1 flu. oz.	8 drachms (fl. dr.)	0·028 ,,	,, 28	,,
1 fl. dr.	3 scruples	0·0035 ,,	,, 3½	,,
1 scruple	20 minims	0·0012 ,,	,, 1·2	,,
1 minim		0·00006 ,,	,, 0·06	,,
			,, 1 drop	

D. Volume – U.S.A.

1 U.S. gallon	4 quarts	3·785 litres	
1 quart	32 fluid ounces	0·9463 ,,	
1 flu. oz.	8 fluid drams	0·02957 ,,	29 c.c.
1 fl. dr.		0·003697 ,,	3·6 c.c.

★ To help with conversions

As a general rule solutions are usually compounded in Britain in quantities of 80 oz. (4 pints or ½ gallon – 1 Winchester), 40 oz., 20 oz., or 10 oz., although among scientists, and recently among photographers, the metric system is in fairly common use.

Conversion to metric measure is much easier if, instead of taking absolute values, *proportional quantities* for *each litre of solution* are calculated.

The table given at head of p. 415 may be used for this purpose. The figures have been rounded off for convenience, but are sufficiently accurate for normal photographic work.

English measure	*Corresponding quantities (grams or c.c.) per litre*			
No. per	80 oz.	40 oz.	20 oz.	10 oz.
1 oz.	12·5	25	50	100
¾ oz.	9	19	37·5	75
½ oz.	6	12·5	25	50
¼ oz.	3	6	12·5	25
10 grains	·25	·5	1	2
1 dram	1·5	3·1	6·2	12·5
10 minims	·25	0·5	1	2·1

★ Note

To convert (approximately) grams (per litre) to grains (per 4 oz.) use the following formula:

(grams × 20) − 10% = grains

and conversely grains (per 40 oz.) to grams (per litre) as follows:

(grains/20) + 10% = grams.

Table G: Conversion from inches to millimetres

Inches	*Mm.*	*Inches*	*Mm.*	*Inches*	*Mm.*	*Inches*	*Mm.*
12	305	4	102	7/8	22·2	9/16	14·3
10	254	3	76	5/8	15·9	7/16	11·1
9	229	2	51	3/8	9·5	5/16	7·9
8	203	1	25·4	1/8	3·2	3/16	4·8
7	178	3/4	19·0	15/16	23·8	1/16	1·6
6	152	1/2	12·7	13/16	20·6	1/32	0·8
5	127	1/4	6·3	11/16	17·5	1/64	0·4

Table H: British Standard sizes to metric

Inches	*Centimetres*	*Inches*	*Centimetres*
1¾ × 2 5/16	4·4 × 5·9	8½ × 8½	21·6 × 21·6
2 × 3	5 × 7·5	8 × 10	20·3 × 25·4
2¼ × 2¼	6 × 6	8 × 12	20·3 × 30·4
2¼ × 3¼	6 × 9	10 × 12	25·4 × 30·4
2½ × 3¼	6·5 × 9	10 × 12½	25·4 × 31·7
3¼ × 3¼	8·25 × 8·25	10½ × 12½	26·7 × 31·7
3¼ × 4¼	8·25 × 10·8	10 × 15	25·4 × 38·1
3¼ × 6¾	8·25 × 17·1	12 × 15	30·5 × 38·1
4 × 5	10·1 × 12·7	12½ × 15½	31·7 × 39·3
4¼ × 6½	10·8 × 16·5	15 × 20	38·1 × 50·8
4½ × 6½	11·4 × 16·5	16 × 20	40·6 × 50·8
4¾ × 6½	12 × 16·5	16 × 21	40·6 × 53·3
4½ × 7¼	11·4 × 18·4	17 × 23	43·2 × 58·4
4¼ × 8½	10·8 × 21·6	18 × 20	45·7 × 50·8
4½ × 8½	11·4 × 21·6	20 × 24	50·8 × 60·9
5 × 7	12·7 × 17·7	21 × 25	53·3 × 63·5
5 × 7½	12·7 × 19	24 × 30	60·9 × 76·2
5 × 8	12·7 × 20·3	25 × 30	63·5 × 76·2
6½ × 8½	16·5 × 21·6	26 × 32	66 × 81·3
7 × 9	17·7 × 22·8	30 × 40	76 × 101·6

Table J: Equivalent quantities of chemicals for substitution in photographic developers

n grams of	*can be replaced by*	*grams of the chemicals below*
Sodium carbonate (cryst.)	$n \times 0 \cdot 37$	Sodium carbonate (anhydr.)
Sodium carbonate (anhydr.)	$n \times 2 \cdot 8$	Sodium carbonate (cryst.)
Sodium sulphite (cryst.)	$n \times 0 \cdot 5$	Sodium sulphite (anhydr.)
Sodium sulphite (anhydr.)	$n \times 2$	Sodium sulphite (cryst.)
Sodium sulphite (cryst.)	$n \times 0 \cdot 44$	Potassium metabisulphite*
Sodium sulphite (anhydr.)	$n \times 0 \cdot 88$	Potassium metabisulphite*

✱ Note: To neutralize the acidity of the metabisulphite, which will reduce the developer activity, the amount of alkali in the developer must be increased at the same time.*

* The different alkalis react with metabisulphite in the following way:

$$K_2S_2O_5 + 2KOH = 2K_2SO_3 + H_2O$$
$$K_2S_2O_5 + 2NaOH = K_2SO_3 + Na_2SO_3 + H_2O$$
$$K_2S_2O_5 + Na_2CO_3 = K_2SO_3 + Na_2SO_3 + CO_2 \uparrow$$
$$K_2S_2O_5 + K_2CO_3 = 2K_2SO_3 + CO_2 \uparrow$$

For each 10 gm. of metabisulphite used in place of sodium sulphite add:

12·4 gm. of potassium carbonate
or 9·5 gm. of sodium carbonate (anhydr.)
or 26 gm. of sodium carbonate (cryst.)
or 3·6 gm. of caustic soda (pellets)
or 5 gm. of caustic potash (pellets)

✱ Example

It is desired to replace 75 gm. of crystalline sodium sulphite by potassium metabisulphite. What quantities should be used?

✱ Answer

75 gm. of sodium sulphite (cryst.) is equivalent to $75 \times 0 \cdot 44 = 33$ gm. potassium metabisulphite. To neutralize the additional acidity there should also be added to the developer:

$$\frac{33}{10} \times 9 \cdot 5 = 31 \text{ gm. (approx.) of sodium carbonate (anhydr.)}$$

Table K: Solubility of various substances

Number of grams that can be dissolved in 100 c.c. of cold water (at about 68°F.)

Acetic acid	(*)	Pot. carbonate (anhydr.)	82
Ammonium bichromate	35	Pot. ferricyanide (red)	35
Ammonium thiocyanate	70	Pot. ferrocyanide (yellow)	25
Borax	7	Pot. metabisulphite	55
Boric acid	4·8‡	Pot. permanganate	6·5
Caustic potash (Potassium hydroxide)	80	Pot. thiocyanate	200
		Pyrogallol	55
Caustic soda (Sod. hydroxide)	80	Silver nitrate	130
		Sod. acetate (anhydr.)	35
Chrome alum	20	(cryst.)	60
Citric acid	85	Sod. bicarbonate	9
Copper sulphate (cryst.)	30	Sod. bisulphite	50
Formaldehyde	(*)	Sod. carbonate (anhydr.)	23
Glycin	(†)	(cryst.)	65
Hydroquinone	6	Sod. chloride (common salt)	30
Lead acetate	45	Sod. sulphite (anyhdr.)	20
Lead nitrate	49	(cryst.)	40
Methyl alcohol	(*)	Sod. sulphide (cryst.)	45
Metol	8	Sod. thiosulphate (cryst.)	90
Oxalic acid	14	(hypo)	
Pot. alum	11	Sulphuric acid	(*)
Pot. bichromate	14	Uranyl nitrate	200
Pot. bromide	54		

* Soluble in all proportions.

† Insoluble in water, soluble however in alkaline solutions and sodium sulphite.

‡ Always use crystalline boric acid, powdered boric acid dissolves only with the greatest difficulty.

If more than the quantity given above is added to water then the excess cannot dissolve. The solubility can, however, be raised by raising the temperature of the solution, but as soon as the solution cools down the amount of chemical in excess will gradually precipitate itself on the bottom of the container in crystalline form. The solubility of any given substance obviously depends not only on the temperature of the solution but also on the degree of purity of the chemical.

The above table should be consulted when stock solutions of various photographic solutions are to be prepared.

Table L: Atomic weights of elements of which substances dealt with in this manual are composed

Aluminium	Al	27	Manganese	Mn	55
Antimony	Sb	120	Mercury	Hg	200
Boron	B	11	Nitrogen	N	14
Bromine	Br	80	Oxygen	O	16
Calcium	Ca	40	Phosphorus	P	31
Carbon	C	12	Platinum	Pt	195
Chlorine	Cl	35·5	Potassium	K	39
Chromium	Cr	52	Selenium	Se	79
Copper	Cu	63	Silver	Ag	108
Gold	Au	197	Sodium	Na	23
Hydrogen	H	1	Sulphur	S	32
Iron	Fe	56	Uranium	U	238
Iodine	I	127	Vanadium	V	51
Lead	Pb	207	Zinc	Zn	65
Magnesium	Mg	24			

To determine the *molcular weights* of any chemical compound simply add together the separate atomic weights of the substances of which it is composed.

★ Example

What are the atomic weights of anhydrous sodium carbonate Na_2CO_3, and crystalline sodium carbonate decahydrate ($Na_2CO_3.10\ H_2O$).

Atomic weights C=12, O=16, Na=23, H=1

Adding the atomic weights:

C	=	12
$3O=16\times3$	=	48
$2\ Na=23\times2$	=	46
Na_2CO_3	=	106

To determine the molecular weight of crystalline sodium carbonate, we must add the weight of 10 molecules of H_2O, that is water, to the molecular weight of Na_2CO_3 that is $10\times(2\times1+16)=180$.

The molecular weight of the crystalline sodium carbonate therefore equals $106+180=286$. From this it can be seen that, when solutions are being made up, 286 grams of crystaline carbonate are equivalent to 106 grams of the anhydrous salt or 100 grams crystalline carbonate=37 grams anhydrous salt.

It is possible in this way to calculate the equivalent amounts of each of the chemicals that are obtainable in crystallized or anhydrous (desiccated) forms, provided the number of molecules of water present in each crystalline molecule are known.

Table M: Comparison of the earlier systems most in use before publishing of A.S.A. Standard PH 2·5–1960

A.S.A. exposure index according to A.S.A. pH 2·5 – 1954	*B.S.I.* (log.)	*DIN*	*Weston*
0·6	9°	—	0·5
0·8	10°	1/10°	0·6
1·0	11°	2/10°	0·7
1·2	12°	3/10°	1·0
1·6	13°	4/10°	1·2
2·0	14°	5/10°	1·5
2·5	15°	6/10°	2·0
3	16°	7/10°	2·5
4	17°	8/10°	3
5	18°	9/10°	4
6	19°	10/10°	5
8	20°	11/10°	6
10	21°	12/10°	8
12	22°	13/10°	10
16	23°	14/10°	12
20	24°	15/10°	16
25	25°	16/10°	20
32	26°	17/10°	24
40	27°	18/10°	32
50	28°	19/10°	40
64	29°	20/10°	50
80	30°	21/10°	64
100	31°	22/10°	80
125	32°	23/10°	100
160	33°	24/10°	125
200	34°	25/10°	160
250	35°	26/10°	200
320	36°	27/10°	250
400	37°	28/10°	320
500	38°	29/10°	400
640	39°	30/10°	500
800	40°	31/10°	650
1000	41°	32/10°	800

★ Note

As is outlined on page 430 the various scales of speeds are determined in very different ways. As a consequence the equivalent values given above are only approximate. These systems are no more used for meter setting recommendations for Gevaert materials. For the latest developments of exposure determination see page 435.

Table N: Recommended meter settings for minimum exposure according to A.S.A. PH 2·5 – 1960

	DIN	*A.S.A.* Speed Number (arithm.)	*A.S.A.* Speed Value (log.)
Roll films			
'Gevapan 27'	17	40	3·5°
'Gevapan 30'	22	125	5°
'Gevapan 33'	25	250	6°
'Gevapan 36'	27	400	7°
'Gevacolor N5'	17	40	3·5°
'Gevacolor R5'	18	50	4°
Miniature films			
'Gevapan 27'	17	40	3·5°
'Gevapan 30'	22	125	5°
'Gevapan 33'	25	250	6°
'Gevapan 36'	27	400	7°
'Dia-Direct 26'	16	32	3°
'Gevacolor N5'	17	40	3·5°
'Gevacolor R5'	18	50	4°
Sheet films (studio films)			
'Gevapan 30'	22	125	5°
'Gevapan 33'	25	250	6°
'Gevapan 36'	27	400	7°
'Gevachrome 32' (daylight)	22	125	5·5°
(artificial light)	19	64	4·5°
'Gevacolor N5'	17	40	3·5°
'Gevacolor N3'	14	20	2·5°
Plates			
'Gevapan 30'	22	125	5°
'Gevapan 33'	25	250	6°
'Gevapan 36'	27	400	7°
'Gevachrome 32' (daylight)	22	125	5·5°
(artificial light)	19	64	4·5°
'Replica 23' (daylight)	13	16	2°
(artificial light)	10	8	1°

Table O: Guide numbers for flash with 'Gevapan' and 'Gevacolor' films

Film used	'Gevapan 30'		'Gevapan 33'		'Gevacolor N5'		'Gevacolor R5'	
Shutter setting	X(1) 1/25 1/30	M 1/100 1/125	X(1) 1/25 1/30	M 1/100 1/125	X(1) 1/25 1/30	M 1/100 1/125	X(1) 1/25 1/30	M 1/100 1/125
Clear bulbs								
PF 1, XM 1, n° 1	176	128	256	176	64	45	—	—
PF 5, XM 5, 25, n° 5	290	210	420	290	105	75	—	—
SM, SF (2)	128	—	176	—	45	—	—	—
Blue bulbs								
PF 1B, XM 1B, n° 1B	—	—	—	—	64	45	64	45

(1) or 'open flash'.
(2) the guide numbers given are suitable for 1/50 and 1/100 with shutter on X setting.

$$\text{Guide number for 'Gevapan 27'} = \frac{\text{Guide number for 'Gevapan 33'}}{2}$$

Guide number for 'Gevapan 36' = Guide number for 'Gevapan' 30 × 2.

The Guide number is the stop number (*f*/No.) multiplied by the distance from the lamp to subject in feet. If you know the guide number and the distance the flashlamp is from the subject then the diaphragm opening (stop number) can be found by dividing the guide number by the lamp subject distance in feet. If because of the need to secure a certain depth of field a certain aperture has to be used the lamp subject distance can be deduced by dividing the guide number by the stop chosen.

★ Example

For a 'Gevacolor N5' film, a flash bulb N° 1 and a shutter speed of 1/25th sec. the guide number is 64. For a lamp-to-subject distance of 8 feet the lens aperture will be 64 : 8 = *f*/8.

II. ELEMENTARY SENSITOMETRY

(see also pages 58 *et seq.*)

Carry out the following experiment (fig. 110*A*). Place an unexposed piece of chlorobromide paper (such as 'Ridax' soft or extra soft) in between a holder made in two sections, one of which has a rectangular opening cut in it as shown in the figure. Expose this sheet of paper in successive steps, pulling the top mask along $\frac{1}{2}$ inch at a time between exposures. If a 15 watt lamp is used at about 3 feet distance the successive exposures can be, for instance, 1, 2, 4, 8, 16, 32 and 64 seconds.

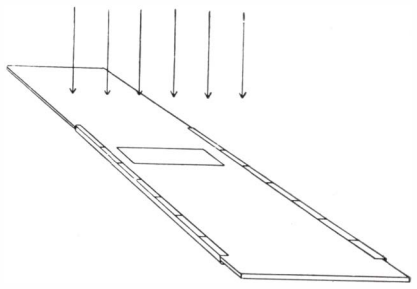
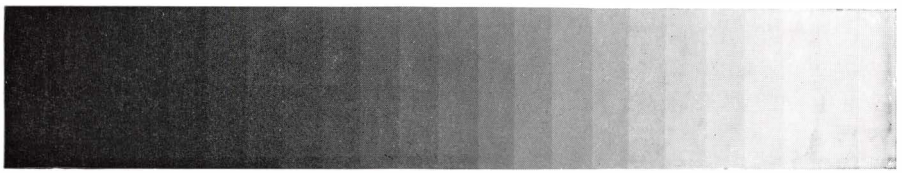


Fig. 110A

If this sheet of paper is then developed and fixed it will have on it a series of 'steps' whose density will increase as the time of exposure has increased.

This method of working has several disadvantages. First of all it is tedious, secondly it is not very precise. Instead of subjecting the sheet of paper to a series of successive exposures the exposures can be made simultaneously behind a 'step-wedge', that is a piece of glass provided with steps each of which has an increasing density. Proceeding say from right to left the density decreases so that each step transmits twice as much light as the preceding, and this ratio is constant from one end to the other. Fig. 110*B* shows the effect produced by



a b c d e f g h i *Fig. 110B*

printing on a piece of paper for a fixed overall exposure through such a wedge. Step (*g*) lets through twice as much light as step (*h*), step (*h*) twice as much as step (*i*), and so step (*g*) 4 times as much as step (*i*), and so on (see also pp. 58 *et seq.*).

If we expose a piece of sensitive material behind such a wedge we obtain the

same result as if we had given the emulsion a series of stepped exposures, each one twice the duration of that preceding. If we then subject several different emulsions to the same procedure we shall observe them to exhibit different characteristics when developed. One emulsion for instance may reproduce the steps of the wedge in such a manner that the density change from one step to the next is a good deal less than it is on the original wedge, on the other hand another material will reproduce the density difference as being much greater than it is on the wedge and a third may reproduce the wedge very much as it is.

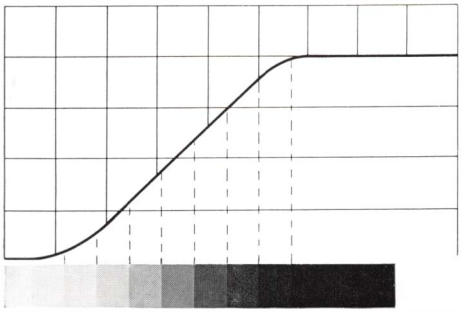


Fig. 111A

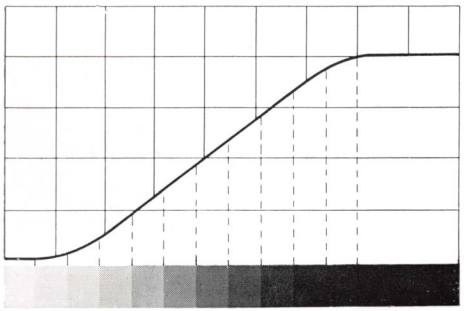


Fig. 111B

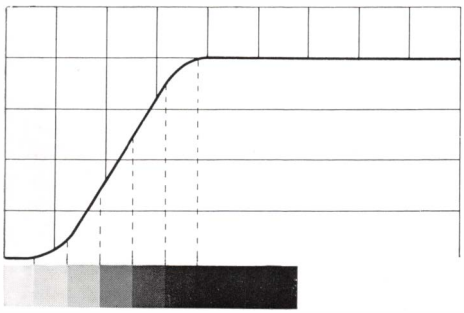


Fig. 111C

Fig. 111 shows this quite clearly. *A* is a normal emulsion, *B* a soft emulsion, *C* a hard or contrasty emulsion. These differences are shown graphically by means of curves (known as characteristic curves). Notice that in *B* there are a large number of small density steps between black and white, in *C* very few, in *A* an intermediate number. To prepare the curves from the step wedge strips we proceed as follows: first measure the densities of each of the steps in a special instrument known as a densitometer.*

The densities so measured can, of course, be represented by lines of corresponding length. If these lines are erected perpendicularly above the step to which they correspond and a line is drawn to join the tops of them as has been done in figs. 111 *A*, *B* and *C*, then

* Two types are usually available, in one a visual match is made while observing a split field through an eyepiece. By turning a control knob or disc the two halves of the field are matched, and the density is then read off on a calibrated dial. The other type is photoelectric and when the sample step is placed in the light beam the density is displayed by a pointer or a dial. Some photoelectric types are automatically recording, this type being used by manufacturers or large laboratories.

we obtain the 'characteristic curve' for each of the three emulsions.

These curves show quite clearly how each of the emulsions behaves when it is exposed to the light of different intensities which come from any given subject. Remember a natural subject will more or less give rise to a similar range of light intensities in the camera, but they will not be arranged in a regular stepped pattern that we can measure so easily and precisely. The curve will rise more steeply (fig. 111 *C*) when there is a greater difference in density between the successive steps of the sample. It is on these simple foundations that the whole science and practice of sensitometry is based. In practice the exposure given to the sample is expressed in logarithmic units. For negative materials a wedge is generally used which allows 10 times more light to pass each 2 cm. ($\frac{1}{2}$ in.) along its length, i.e. a density difference or increase of log exposure units of 1·0. The *wedge constant*, i.e. the increase of density per 1 cm. ($\frac{1}{4}$ in.) of length, is then said to be equal to 0·5. In the curve given in fig. 112*A* the horizontal axis (the abscissa) shows the exposure given in logarithmic units. These numbers correspond to values of intensities for a single fixed exposure *time* as follows:

Logarithmic unit	0	1	2	3	4
Intensity (or exposure)	1	10	100	1,000	10,000

For papers the wedge used generally has a constant not exceeding 0·25 (per cm.) and rather less for contrasty emulsions.

The vertical axis (ordinates) represents the density measured on the sample film or paper. So that the precise meaning of the term density can be better understood one or two necessary definitions are given below:

The *Transmission* of a silver deposit or layer (density) is given by the ratio of transmitted or reflected intensity (I′) and the incident intensity (I).

Formula: T=I′/I. For example, if an area of a negative or print allows 10% of the incident light to pass, or be reflected, then the transmission T=1/10 (10/100).

The *Opacity* is the reciprocal of transmission, i.e. O=I/I′, for the example given above O=10.

The *Optical Density* is the logarithm of the opacity, i.e. for the example above D=log. *Op*=log. 10=1.

Now let us take point B on fig. 112*A*. Drop a perpendicular (dotted) to the horizontal axis: it intersects the exposure scale at a point between 3 and 4, say 3·8 – this is the logarithm of the *exposure*. A horizontal line through B to the density axis on the left gives a value of 2·8 (in between 2 and 3). This is the corresponding *density* produced in the sample of material being measured. The opacity of this point is the antilog of 2·8, i.e. 630 and the transmission of this sample is 1/630th.

The characteristic curve

Examination of the curve of fig. 112*B* shows that it is composed of a straight line middle portion and two curved parts one at the beginning or toe, the other at the upper end, or shoulder.

The *straight line portion* corresponds to that part of the step wedge which the emulsion reproduces proportionally, i.e. in this part the densities produced behind each step increase by fixed amounts, or ratios. This is not so in the toe region, where the contrast (or density difference) increases gradually as we move from left to right, nor is it so in the shoulder region, where the opposite effect is observed, the increase in density gradually becoming less and less.

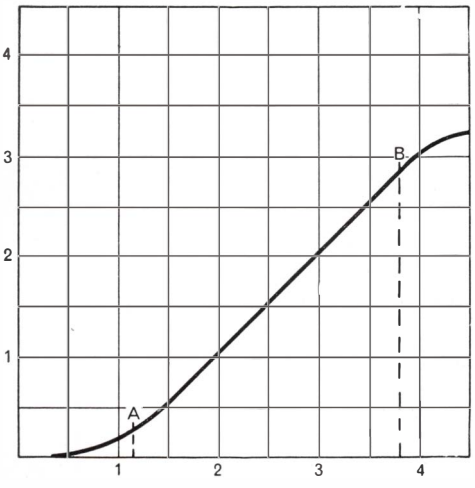


Fig. 112A

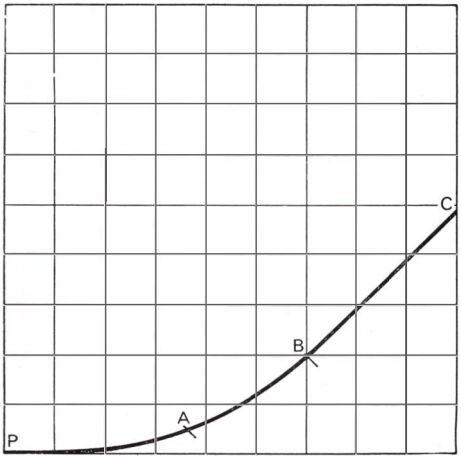


Fig. 112B

The exposure is said to be 'correct' when the densities concerned are produced in the straight line portion of the curve. To determine the region of correct exposure we drop a perpendicular to the exposure axis from each end of the straight line where it changes direction (see A and B, fig. 112*A*). The difference between the exposure values intercepted by these perpendiculars on the horizontal axis is $3 \cdot 8 - 1 \cdot 2 = 2 \cdot 6$ and this corresponds to an exposure range of 1 : 400 (log $2 \cdot 6 = 400$). To find the *exposure latitude* (or range of correct camera exposures) this figure has to be *divided* by (or their logarithms subtracted) the subject brightness range. If, for example, the scene is a landscape with foreground for which the brightness range of 40 : 1 (i.e. a log value of $1 \cdot 6$) the *exposure latitude* will then be

$\frac{400}{40} = 10$ (i.e. in logs : $2 \cdot 6 - 1 \cdot 6 = 1 \cdot 0$)

this means that if, say, an exposure of 1/50th sec. is just sufficient to ensure that the darkest shadow required is at point A on the curve of fig. 111, then an exposure time of 10 times this duration, i.e. 1/5th sec., at the same aperture of course, will still be quite satisfactory. Of course a negative taken with 1/5th sec. will be much more dense, and will require more printing exposure, perhaps

even as much as 10 times, but as far as the gradation is concerned the result will be just as good.

From what has been said above it follows that the exposure latitude depends on the brightness range of the subject itself. For instance, if we were to photograph an outdoor partly 'against the light' shot with a brightness range of 400 : 1 (i.e. log 2·6) the exposure latitude of the negative material discussed above could be

$$\frac{400}{400}=1$$

so that unless we alter our working conditions then there is only one '*correct*' exposure for this type of scene. The exposure latitude becomes smaller as the subject brightness range increases.

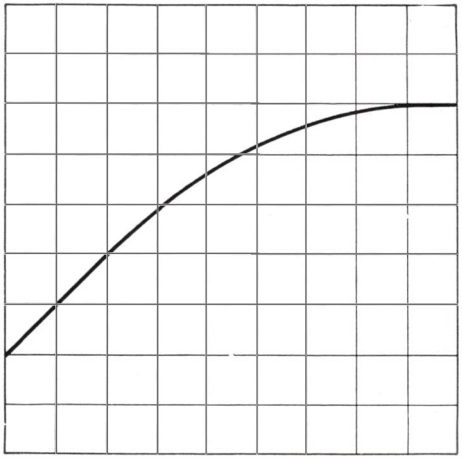


Fig.113

The *toe* of the curve, in which the density increased at a gradually increasing rate (or slope), is the region of under-exposure (see fig. 112*B*). Negatives exposed in this region, as is shown by fig. 112*B*, will have shadow areas which are less well separated than the middle and highlight tones, particularly if an energetic developer is used. Portion PA, which corresponds to the shadow areas, shows only a slight density increase; compared with this, portion BC, which will correspond to the highlights, is much steeper.

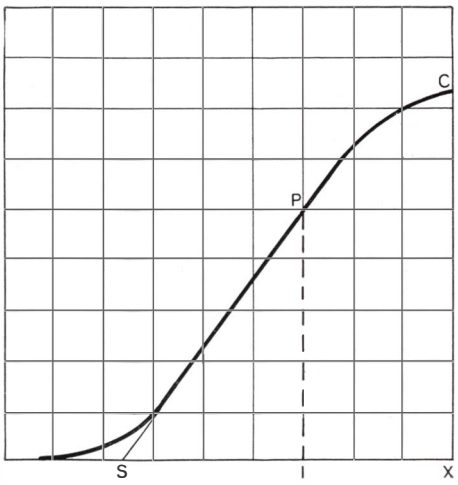


Fig. 114

The *shoulder* or upper zone of the curve is the region of over-exposure. The curve flattens off more or less completely (fig. 113). Negatives sufficiently over-exposed to record in this region will have considerably reduced contrast, especially in the lighter tones and highlights.

Gamma (γ) or degree of contrast

If the straight line portion of the curve is carried downwards to intersect the horizontal axis it will make an angle PSI (fig. 114). This angle is a

measure of the slope of the straight line portion of the characteristic curve.

To give the slope as a single characteristic number, first drop a perpendicular from any point on the straight line (say P) to the horizontal exposure axis, this can be as shown PI. The ratio PI/SI/SI which is the tangent of the angle PSI is called the *gamma* of the straight line portion of the curve. To measure this ratio, simply take the number of divisions on the graph cut by these two lines and divide one by the other, provided the same scale is used in both directions. In this case we have:

$$\gamma = \frac{5 \cdot 0}{3 \cdot 5} = 1 \cdot 4$$

An emulsion of normal gradation is usually one in which the gamma is about 1·0 for the recommended development, i.e. the angle is about 45°. The precise value required depends upon the type of work (i.e. the nature of the subject). The professional portrait photographer frequently prefers development to a lower gamma, i.e. prefers a soft negative, whereas process workers, particularly for line reproduction, attempt to procure as high a gamma, i.e. as steep a curve, as possible.

It is of course essential to bear in mind the gradation of the paper which is to be used for printing. Remember that an enlarger with diffuse illumination will give considerably softer results than one with condenser illumination. For use with a diffuser type enlarger it is better to use a contrastier negative (with a higher gamma). A normal negative will then be printed on a medium contrast paper, so that there are in reserve a sufficient number of paper grades both harder and softer which can be used to produce a different result, whatever the brightness range, and the resulting negative density range, may be.

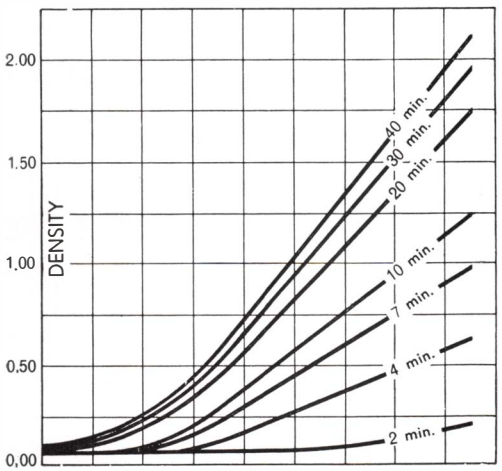


Fig. 115

Gamma and time of development

The *value of gamma depends upon the time of development.* Fig. 115 shows curves which correspond to different times of development for the same exposure. It can be seen from the curves that the gamma increases progressively as the development is prolonged. There is of course a limit. After a certain development time is reached, this differing for each emulsion, the gamma is substantially constant. This value is

called 'gamma infinity' ($\gamma\infty$). This is more or less independent of the developer used, and depends only on the particular emulsion used. $\gamma\infty$ is, therefore, a characteristic of the emulsion.

Positive emulsions and contrasty process emulsions have a $\gamma\infty$ which is a good deal higher than that for normal negative type emulsions. The time required to reach $\gamma\infty$ depends on the constitution and the concentration (dilution) of the developer, as well as on the temperature, and the degree of agitation used. $\gamma\infty$ is soon reached in an energetic developer, and rather slowly in a soft working developer; in fact the difference between these two types of developer is simply that in the first type the negative reaches various values of gamma much more rapidly than it does in the second.

The curves of fig. 115 refer to a given film processed in one given developer, for varying times at a fixed temperature and a given degree of agitation. They show that the gamma increases rather rapidly during the first 10 minutes or so, and thereafter increases at an ever decreasing rate. This is a good deal easier to see if we prepare a curve showing the increase of gamma with time of development, i.e. a *gamma-time curve*. See also Part II, p. 185.

SPEED

The determination of speed is of great practical importance. Moreover, it is the main *raison d'être* of the science of sensitometry which was originally conceived mainly as a method of determining sensitivity.

H & D

The first scientific researches in this field were undertaken by Hurter and Driffield. Starting from the characteristic curve these two workers postulated that a correctly exposed negative must be such that for equal increases in brightness in the subject there must be equal increments of density in the negative. It follows from this proposition that, as we have already seen, only the straight line portion of the negative material characteristic curve can play any part in the process and must, therefore, be used to determine the sensitivity of the material. Therefore to determine the speed Hurter and Driffield extended the straight line portion of the curve to cut the horizontal exposure axis at a point I (see fig. 116). They called the distance O I the *inertia*, and this inertia determined the speed. The smaller the distance O I the higher the sensitivity.

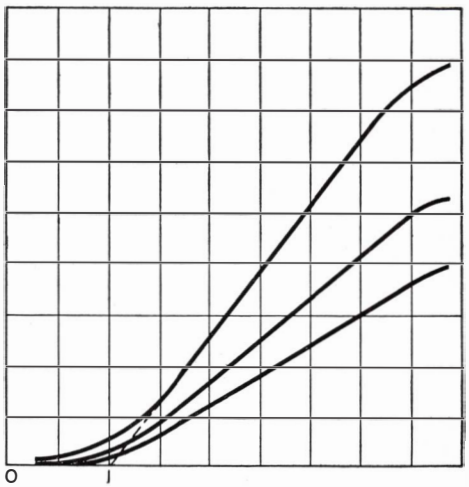


Fig. 116

The speed number was calculated from the following formula:

$$\text{H \& D speed} = \frac{34}{\text{O I}}$$

In this formula 34 is an arbitrarily chosen constant and O I is measured in metre-candle seconds.*

Note that in fig. 116 the straight line portions of all three curves meet at a single point I, even though the degree of development, i.e. the gamma, has been changed. This means the speed is independent of the gamma. This is, however, only true when a developer which does not contain soluble bromide is used; with most commercial developers and a large number of double-coated negative emulsions, which do not have long straight portions, the speed changes with gamma (a fact known to most practising photographers in their work). When a normal developer is used compounded with potassium bromide or which contains soluble bromide from use these lines may still meet in a point, it is true, but at a point below the horizontal axis, and may in some cases not meet at all, so that it is impossible to assign a unique 'speed-figure'. This is undoubtedly a grave disadvantage which in practice applies to all developers containing soluble bromide ions. It is an additional disadvantage of the Hurter and Driffield method that it takes no account of the toe of the curve, which has some importance especially for portrait workers.

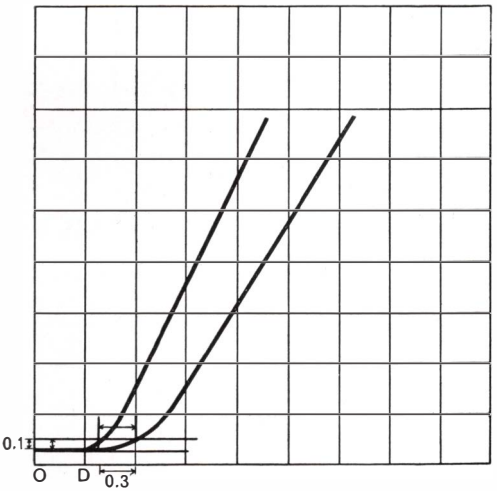


Fig. 117

Scheiner

The *Scheiner* method of determining speed uses the threshold of sensitivity of the emulsion as a starting point. The threshold illumination is defined as the amount of light that is just sufficient to produce a developable effect on the sensitive layer. It is not therefore the inertia (distance O I on fig. 116) but instead the distance O D (fig. 117) which determines the sensitivity. Hurter and Driffield used a characteristic curve obtained by exposing their test material behind a wedge (we call this an intensity-scale exposure) whereas in Scheiner's method a rapidly rotating sector wheel was used for the exposure, in which the sector length was varied progressively. A strip of the negative material under test some 2×9 cm. is exposed behind the rotating sector wheel. The wheel

* A standard source of one candle power illuminating a surface one metre distant for one second, or an equivalent exposure.

turned for a minute at a pre-determined speed so that one end of the strip received 100 times more exposure than the other. A small plate held in front of the negative divided the field of the 2×9 cm. into 20 separate fields numbered 1 to 20. Obviously for determining the speed of any material there had to be a light source constant in both intensity and spectral composition. The last figure to be just visible (because it could just be made out against the background) gave the sensitivity in 'degrees Scheiner', e.g. 19° Sch. The Scheiner method had the advantage that the 'speed number' could be determined without having to plot the characteristic curve. On the other hand the chief objection to it was that in practice the absolute threshold has little or no importance because negative densities can hardly be printed right down to the threshold. In addition, as is shown in fig. 117, the Scheiner system gives too high a speed for materials (like many high speed negative emulsions) which have a long toe portion. This figure shows the characteristic curves of two emulsions with the same speed rating on the Scheiner system. However, if a density of 0·1 above fog is required the short-toe emulsion is twice as fast as the long-toe emulsion.

Note: Since the interval 1 : 100, i.e. log 2·0 was divided into twenty parts, each increment was equivalent to a log change of 0·1; three such steps give log 0·3 which is exactly 2X. An increase (or decrease) of 3° Scheiner therefore corresponds to a doubling (or halving) of speed. This logarithmic speed system is still used for both continental and British speed systems of the present day.

For upwards of twenty years the two methods just described were debated on all sides. Their principal shortcomings were mentioned as we went along. We must remark also that the light sources used for making the exposure – in the H & D system a candle or a standard incandescent electric lamp, and in the Scheiner system a petrol lamp – both gave light of a spectral quality quite different from normal daylight. Faced with these drawbacks, which were not the only ones, the scientists of various countries set to work to find a method of defining and measuring speed of the desired precision. The principal methods were:

1. Weston.
2. A.S.A. (American Standard Association).
3. B.S.I. (British Standards Institution).
4. D.I.N. (Deutsche Industrie Normen).

Weston system

This system uses the straight line portion of the curve to determine the speed. The Weston speed figure, which is an arithmetical figure (like H & D), is derived from the following formula:

$$W = \frac{4}{i}$$

4 is an arbitrary constant and i is the exposure required to produce a density

above fog equal to the gamma, i is expressed in the candle-metre-seconds (see footnote p. 429).

If, for instance, $\gamma = 0 \cdot 8$, point W on fig. 118 is at the foot of the perpendicular where $D = 0 \cdot 8$ intersects the curve. From W, i and consequently the speed can be evaluated. There is a fixed relationship between the H & D speed and the Weston speed. If as is the case in America, the arbitrary number in the H & D formula is taken as 10 instead of the original 34 which was more suitable to the emulsions of 1900, then the relation is as follows:

$$W = 0 \cdot 04 \text{ H \& D}$$

$$\text{H \& D} = 25W$$

The Weston system uses the same standard light source as the D.I.N. Development is in the developer recommended by the manufacturer and to the gamma normally used with that material. This method is no longer being used.

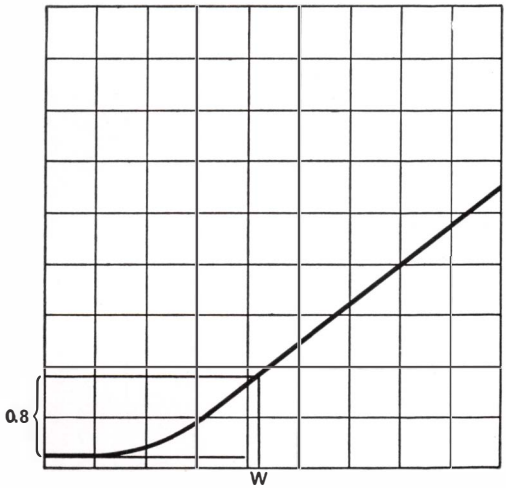


Fig. 118

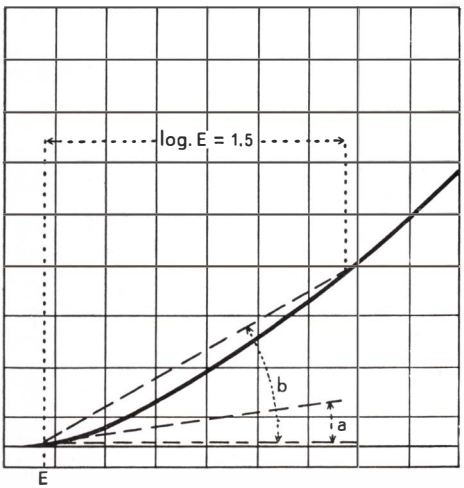


Fig. 119

The A.S.A. system

This method is based on the concept of minimum useful gradient. This idea was first put forward by Jones and Russell at the International Congress of Photography in 1928. The method was developed during the last war by the Americans and English workers and is now the basis of the A.S.A. and B.S.I. standards.

The light source is sensibly the same as daylight (mean noon sunlight). The conditions of exposure and development are precisely standardized. The speed is determined from the characteristic curve in which the ordinates correspond to densities measured on the sample, and the abscissa the logarithm

to base 10 of the exposure measured in candle metre seconds (see footnote p. 429). The formula is:

$$\text{A.S.A. speed} = \frac{1}{E}$$

Where E is the exposure *corresponding to the point on the characteristic curve where the gradient (a) is equal to* 0·3 *the average gradient (b) measured over an exposure interval of* 1·5 *log units starting from point E.*

Fig. 119 shows these values clearly. This point where the gradient (or slope) is equal to 0·3 the average gradient, which is vertically above the point E on the exposure axis, is found with the aid of an 'A.S.A. meter' specially designed for the purpose. The average gradient (i.e. tan. *b*) should not be less than 0·5 and in the case shown is 0·58. From E exposure indices can be calculated. For instance if E = 0·01 metre candle seconds, the A.S.A. speed is 1/0.0·1 = 100.

The A.S.A. speed therefore corresponds to the smallest amount of exposure capable of yielding the 'first excellent print'. It was considered that, if one relied on values so derived, in practice there was a risk of under exposure. To avoid this it was decided to provide a safety margin, to give an exposure 2·5× greater. Therefore the method of defining the exposure index was fixed as 1/2·5 E.

In 1960, a new A.S.A. Standard was published in order to find a compromise between the 'fractional gradient method' of the earlier A.S.A. Standard of 1954 and the fixed density method of the DIN system (see page 435, 'The latest developments of speed determination'.)

B.S.I. speeds

B.S.I. speeds are determined in exactly the same manner as A.S.A. speeds but are expressed, not on an arithmetical scale, but on a logarithmic scale like the speeds in the D.I.N. and Scheiner systems where 3° added corresponds to a doubling of speed. The point of correspondence is at 25–25° B.S.I. = 25 A.S.A. so that an arithmetic speed of 1,000 corresponds to a logarithmic index of 41° and one of 500 to 38°.

D.I.N. method

This system is similar in some respects to the Scheiner system. Instead of taking the point where the density is just perceptible to the eye the density which is read off is taken at a point 0·1 above the background fog. In this way it is possible to eliminate from consideration in determining the speed that section of the curve which has no practical value. Fig. 120 shows how this value is determined. Point A is the point where the curve reaches a density value which is 0·1 density units above the fog. The intersection D where the perpendicular from A cuts the horizontal exposure axis gives the speed figure. Just as is the case with the Scheiner method it is not necessary with this system to plot the

curve. As soon as the exposure has been made, and the sample processed, the number on the wedge corresponding to a density of 0·1 above fog is read off on a specially designed apparatus. If for instance this number is 2·1 the speed is given as:

$$\frac{21^{\circ}}{10}\text{D.I.N.}$$

In the D.I.N. system normal criteria are used throughout. In this method the sensitive material under examination is exposed behind a step wedge which increases in density by 0·1 per cm. The exposure is made in an apparatus specified by the D.I.N., in which is mounted a light source corresponding to noon sunlight, i.e. with a colour temperature of 5,000°K. (a vacuum tungsten lamp behind a Davis-Gibson filter). The distance from the light source to the film is set so that the intensity at the wedge, with the filter removed, is 40 metre-candles (lux). The exposure time is 1/20 sec. The exposed films are processed in a specified MQ developer with vigorous agitation until the maximum speed is obtained, without regard to the actual time of development. To make this system correspond more accurately to actual practice it was modified by a new D.I.N. standard, published in 1957 and generally referred to as Neo-D.I.N. This new standard adopts the developer and the method of development specified for the A.S.A. standard determination, which approaches much more closely to actual practical conditions. The method of determination of the speed figure remains unchanged.

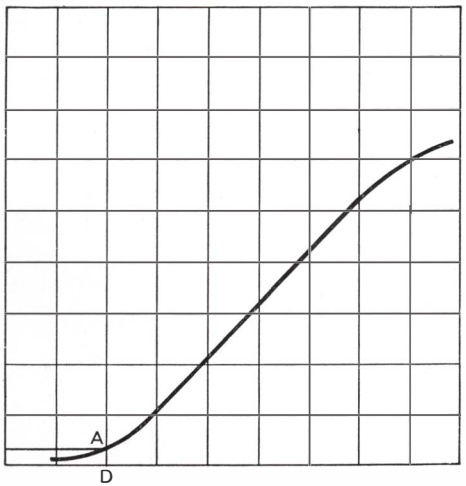


Fig. 120

In order to distinguish clearly between the speed figures given by the new D.I.N. standard and those obtained by the old method, a different way of setting them out is specified:

old D.I.N. system: $\times/10^{\circ}$ D.I.N.
new D.I.N. system: $\times^{\circ}$ D.I.N.

The expression of the speed number as a fraction is thus abandoned, so that there is no risk of confusing the different values.

The new D.I.N. system is very close to the A.S.A. method. The exposure and the method of development of the test strips are identical, only the method of determination differs. Because of this it is possible to determine a fixed relationship between the A.S.A. and D.I.N. speeds – that is 21° D.I.N. = 100 A.S.A.

★ Note

If the various methods are compared it will be seen that each uses different criteria on which to base the speed measurement. It is hardly surprising therefore that this gives rise to great divergencies in the estimation of speeds, particularly as the shape of the foot of the curve plays a predominant part.

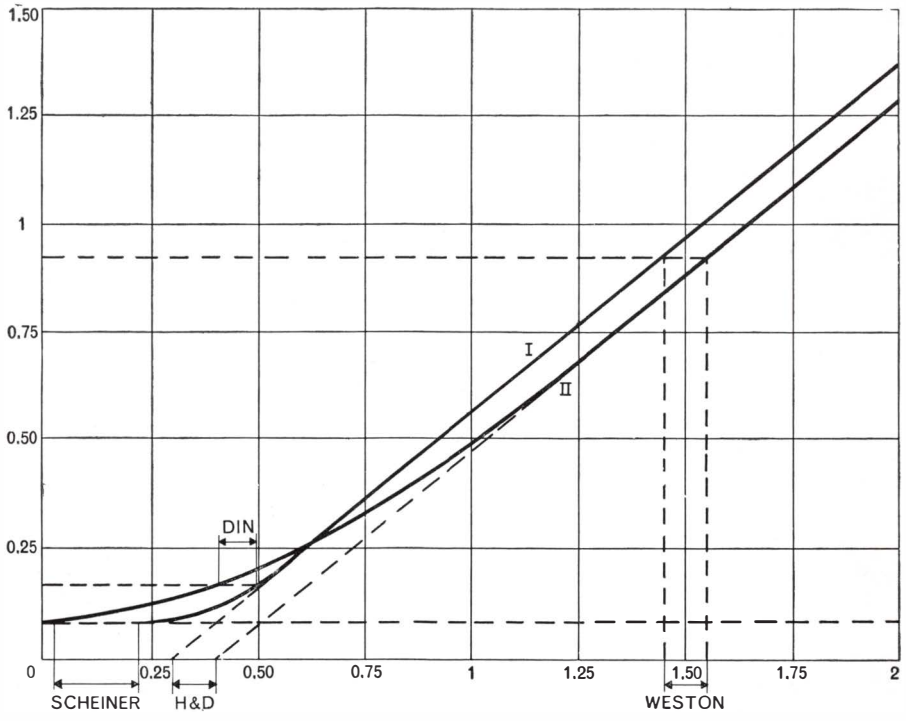


Fig. 121

In fig. 121 are shown two characteristic curves of the same gamma (γ). The speed figures derived from them on the H & D and Weston systems are in agreement, which is only to be expected from what we have said before. It is a different matter, however, when we come to compare the Scheiner, D.I.N. and H & D or Weston systems: according to the Scheiner and D.I.N. systems emulsion II is faster than emulsion I, according to the H & D and Weston system the opposite is the case: I is faster than II. In order not to overload the diagram we have not shown the A.S.A. speed determination but in fact it can be shown that on this system II is faster than I.

It is fairly easy to see from this that the Sch., D.I.N. and A.S.A. systems favour emulsions with long shallow foot sections, whereas the H & D and Weston systems take little or no account of the toe of the curve.

There are a number of additional considerations which could be discussed in relation to the advantages and disadvantages of the various methods of measuring speed, but space is limited. Sensitivity is a complex property not easily or exactly expressed by a single figure, as say temperature or voltage can be. As we will see now the researches that are continuously in progress will lead to a system which will satisfy all reasonable needs. A comparison of the earlier speed scales is given in table M, p. 419.

★ The latest developments of speed determination

During recent years a number of manufacturers as well as indicating the standard speed of their negative films have also specified a maximum speed, at least so far as high speed emulsions are concerned. Thus, for example, a film of 25° D.I.N. is accompanied with the information that excellent results can be achieved at 28° D.I.N. This higher speed, which is quite attainable, while apparently inexplicable, is obtained by a reduction in the safety factor which for A.S.A. (and B.S.I.) exposure indices is 2·5. This has resulted in, among other things, some competition in claiming the maximum speeds realizable in practice. This is one of the reasons which led the American Standards Association to review its standard for the speed of amateur black and white negative films and to reduce considerably the original safety margin provided. This new A.S.A. standard was published on 1/4/1960 under the number A.S.A. PH 2·5 – 1960.

Formerly in fixing the A.S.A. 'exposure index' the variations in cameras and exposure meters were properly taken into account, as well as possible errors in processing. This explains the safety factor of 2·5 × (1·1/3 stops) we have already referred to.

The use of this safety factor was obviously equivalent to reducing the maximum speed. As we have already said the introduction of this factor was amply justified by the fact that the measured A.S.A. speed represented the minimum exposure, and that increased exposure would cause no harm to the image quality, at least as far as the relatively larger negative sizes of 6 × 9 and 9 × 12 cm. ($2\frac{1}{4}$ in. × $3\frac{1}{4}$ in., and $3\frac{1}{4}$ in. × $4\frac{1}{4}$ in.) were concerned, and which in general were intended preponderantly for contact printing. A rather higher density in fact was no disadvantage during printing. In the Weston and G.E. Exposure Meters, which were very much in use at this time, the safety factor was further multiplied by 1·6, so that these instruments in fact assured a safety margin of two whole stops.

The growth in popularity of miniature cameras and the progressive tendency to move from 9 × 12 cm. and 6 × 9 cm. towards 6 × 6 cm. and 4 × 4 cm. made the need for a correct exposure much more critical; over-exposure with these sizes resulted in poor definition and increased graininess, and resulted in lower print quality (as well as increased enlarging times).

As a consequence the A.S.A. exposure index no longer corresponded to the needs of a technique which was now in common use.

In the revised A.S.A standard (PH. 2·5 – 1960):

(*a*) The safety factor has been reduced from approx. 2·5× to approx. 1·2×.

(*b*) The A.S.A. values are known as 'speed-numbers' to distinguish them from the previous 'exposure-indexes'.

(*c*) A logarithmic scale is provided; this gives 'speed values' expressed in ° (degrees) and the scale runs from 1 to 10° (for example A.S.A. 6°). These values are related to a new additive system APEX (*A*dditive system of *P*hotographic *EX*posure) described below.

(*d*) No difference is now made between the speed figures for panchromatic films for photography by daylight and by artificial light since exposure meters now have a spectral sensitivity close to that of the emulsions. A difference however is still needed when the sensitivities of ortho films to daylight and to artificial light are specified.

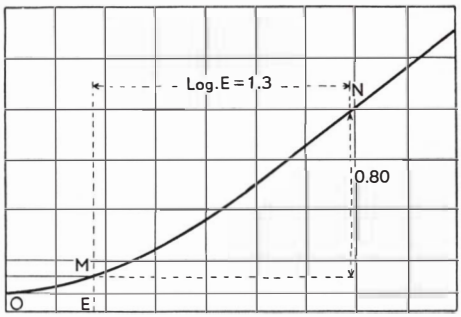


Fig. 122

★ Sensitometric derivation of speed by the new revised A.S.A. Standard pH 2·5 – 1960

The method for determining speed is illustrated by fig. 122. In this figure the density-log exposure curve of a photographic material is plotted for the developing conditions specified in the standard. Two points are shown on the curve at M and N. Point M is located 0,1 above fog-plus-base-density. Point N lies 1·3 log exposure units from point M in the direction of greater exposure. The developing time of the negative material is so chosen that point N lies at a density interval of 0·80 above the density at point M. When this condition is satisfied, the exposure E, corresponding to point M, represents the sensitometric parameter from which speed is computed.

The arithmetic speed can be computed by the formula: $Sx = \frac{0{\cdot}8}{E}$

where Sx is the speed (arithmetic) and E is the exposure (expressed in meter-candle-seconds) corresponding to the point M on the density curve at which the density is equal to 0·10 plus base and fog density.

The logarithmic speed can be computed by the formula: $2\,Sv = \frac{0{\cdot}24}{E}$

where Sv is the speed (logarithmic) and E is the exposure corresponding to the point M as defined above.

For comparison of the new A.S.A. scales with the D.I.N. scale, see Table I, page 437. Recommended meter settings for Gevaert films and plates are mentioned in Table N, page 420.

Table I

Comparative table of sensitivity scales in ASA (arithm.), °Din and °ASA (logarith.) after publication of the ASA standard PH 2·5—1960.

ASA arithm.	°DIN	°ASA log.
3200	36	10
2500	35	9.5
2000	34	
1600	33	9
1250	32	8.5
1000	31	
800	30	8
650	29	7.5
500	28	
400	27	7
320	26	6.5
250	25	
200	24	6
160	23	5.5
125	22	
100	21	5
80	20	4.5
64	19	
50	18	4
40	17	3.5
32	16	
25	15	3
20	14	2.5
16	13	
12	12	2
10	11	1.5
8	10	
6	9	1
5	8	0.5
4	7	
3	6	0
2.5	5	

★ What has happened in practice

(*a*) The A.S.A. speed figures for black and white amateur films for general photography have been practically doubled by the introduction of the new standard, although the materials themselves have undergone no change at all. The exposure indices of colour-films and of reversal black and white films have remained unchanged. For these emulsions moreover the relationship A.S.A. 100 – 21° D.I.N. can be applied as well as the A.S.A. 'speed value'.

(*b*) The new A.S.A. Standard has been put forward by the U.S.A. to the I.S.O. for adoption as the international Standard.

(*c*) The new 'speed numbers' and 'speed values' of the A.S.A. standard utilize the practical minimum exposure. Since this is so we feel we must emphasize that as the sensitivity of the films themselves has not been changed, adequate precautions must be taken in the exposing technique to ensure that the negatives receive sufficient exposure to give the quality we know from experience that we require.

★ A new additive system for exposure values (APEX)

The use of the different settings needed to produce a given exposure has always been considered a nuisance by amateurs.

It must be admitted that it is not always the easiest thing to do to use with the various indices A.S.A., D.I.N. and the other diaphragm openings which get larger as the stop number gets smaller, exposure time in fractions of a second and exposure meters (calibrated in various light units). A very great simplification was brought about by the introduction of the 'Light Value System' (L.V.S.) both on cameras and on exposure meters. All that is needed, with this system is to read off on an exposure meter, set for the film in use, the exposure value indicated, and to set this on the corresponding scale provided on the lens setting ring. The exposure values are provided as a series of numbers from 0 to 18, and an increase of 1 in the number indicates a doubling of the exposure.

It has been proposed to develop this system into an additive system embracing all the factors involved in exposure so that the determination of the correct exposure required is reduced to a simple calculation.

This system, called APEX (*A*dditive system of *P*hotographic *EX*posure), is also proposed by A.S.A. The traditional values are replaced as follows:

The *shutter speed* is replaced by a 'Time value' scale running from 0 to 10.

The *diaphragm openings* (*f*/numbers) are denoted by a set of 'Aperture values' which run from 0 to 10 and in which the size of the opening decreases with the numbers.

The *speed numbers* are replaced by the new A.S.A. 'Speed Values' from 0 to 10.

The *scene brightness values* measured by exposure meters are given on a scale of 'Brightness values' from 0 to 13. The relationship between these new values and those conventionally in use is shown in Table II (below).

The essence of this new system is to equate the 'exposure value' which is given as the sum of the 'speed value' and the 'brightness value' to the sum of the 'time value' and the 'aperture value':

Thus

Speed value + Brightness value	=	Exposure value	=	Time value + Aperture value

Example

Speed value 5 (A.S.A. 100) + Brightness value 7	=	Exposure value 12	=	Time value 7 (1/125 sec.) + Aperture value 5 (f/5·6)

Every combination of shutter speed and aperture setting whose 'values' add up to 12 will give the correct exposure.

From examination of Table II it can easily be seen that the scale of values in

Table II
A new additive system for exposure values (Apex)

ASA speed value	*ASA speed number*	*Brightness value*	*Brightness of the subject* *	*Aperture value*	*f/stop*	*Time value*	*Shutter speed*	*Exposure value*
							(*sec.*)	
0	3	0	0·352	0	*f*/1	0	1	0
1	6	1	0·704	1	*f*/1·4	1	1/2	1
2	12	2	1·41	2	*f*/2	2	1/4	2
3	25	3	2·82	3	*f*/2·8	3	1/8	3
4	50	4	5·63	4	*f*/4	4	1/15	4
5	100	5	11·3	5	*f*/5·6	5	1/30	5
6	200	6	22·5	6	*f*/8	6	1/60	6
7	400	7	45·1	7	*f*/11	7	1/125	7
8	800	8	90·1	8	*f*/16	8	1/250	8
9	1600	9	180	9	*f*/22	9	1/500	9
10	3200	10	360	10	*f*/32	10	1/1000	10
		11	721					11
		12	1442					12
		13	2884					13–18

* Brightness of the subject expressed in candle/ft.^{2}

each column all go in the same direction at the same rate, from 0 to 10 or more, the same increase or reduction in value in any column produces the same effect on the final exposure value. Each value requires an exposure half that of the preceding value.

Another advantage is that filter factors—often the cause of errors – can be replaced by numbers 1, 2, 3 which can simply be deducted from the exposure value to give the correct exposure (they may equally well be deducted from the 'speed value'). A filter with a factor of 1 × (no increase of exposure needed) will then have a value of 0, a filter factor of 2 × the value 1 etc.

Briefly the new additive system has the great advantage of reducing to one simple operation, what has been heretofore the somewhat complicated calculation of the correct exposure required, and it operates with a precision of $\frac{1}{2}$ stop, and is just as satisfactory for colour as for black and white work.

III. VARIOUS PHOTOGRAPHIC EFFECTS

It has occurred to us that some of our readers might find it interesting to be told something about a number of effects which are often mentioned in the photographic literature without any explanation. They are generally called after the research worker who first discovered or described them.

The list below will serve as a useful reference. It is arranged in alphabetical order.

Albert effect

If a fully exposed collodion plate is immersed in nitric acid, it loses most of its speed. A negative plate so treated and then exposed to white light will yield a positive image. Lüppo-Cramer showed a good deal later that the same effect could be produced with silver bromide emulsions and that nitric acid could be replaced by dilute chromic acid, ammonium-persulphate and other suitable oxidizers.

Callier effect

Condenser enlargers using a clear lamp with point source filament will give enlargements which are much more contrasty, other things being equal, than those made with diffusely illuminated enlargers. This effect is due to the fact that the collimated light from the condenser passes freely through the clear areas of the negative, just as the diffuse light does, but in the darker areas the diffuse light passes with less loss since the collimated light loses a part from direct absorption and a good deal more by internal multiple reflections and diffusion or scattering, which, since it is already a feature of diffuse illumination, has little or no effect on it. Hence the great increase in contrast.

Clayden effect (sometimes also called 'black lightning')

When lightning is photographed and the shutter is then reopened to expose for the surrounding country, then it often happens that the image of the lightning disappears or is reversed in tone, so that the lightning streak appears black on the print. Experiments have shown that this effect can only be produced:

1. After lightning flashes lasting less than 1/50th sec.
2. When followed by an exposure to a medium intensity.

The same effect can be produced with sparks from a Leyden jar. This effect is considered to be similar to solarization.

A similar effect can also be produced by cathode rays (electrons).

Eberhard effect

Areas which ought to have equal densities on the negative sometimes develop up with densities greater than one another, small areas being darker than large areas. In addition it can be shown that large areas of density with well defined edges are slightly denser at the edges than they are in the centre of the areas of density (edge effect). These effects are due to variations in the developer concentration and activity in the emulsion layer. On large areas of blackening the developer is not replenished so rapidly as it is over smaller areas unless there is the most violent agitation and because of this the density is usually slightly lower. At the edges moreover the regeneration of developer (i.e. the dispersal of soluble bromide) is much more rapid because of the proximity of little or no exposed areas where no developer is being used.

This effect manifests itself more strongly on thick emulsions than on thin. It is increased by diluting the developer, but decreased as the time of development is increased.

Herschel effect

If plates, papers or films which are not sensitive to red light are, after they have been normally exposed, subjected to the action of red radiations the latent image is much reduced or even destroyed. The reduction is greater according as the first exposure is more intense. It follows from this that non-colour-sensitive or ortho-sensitized plates, films and papers should not be exposed to red light between exposure and development. Plates and films treated with desensitizers and then developed in red light may have their images greatly reduced or even destroyed. On the other hand Lüppo-Cramer has reported much more recently that plates and films desensitized in pinacryptol yellow or green do not suffer from the disadvantage of loss of fine shadow detail.

The Herschel effect shows up at first as a loss of contrast. This effect can therefore be used to soften over contrasty prints (for instance if one is without paper of the desired contrast grade). It is sufficient, after exposure and before development, to leave the print for a little while under the light red safelight. This process is however fairly difficult to control.

Intermittent effect

Related to the Schwarzschild effect (see opposite).

If a given exposure, say 50 seconds at a given intensity, is split up and given to the emulsion as, say, fifty exposures each of 1 second the same amount of blackening (i.e. density) is not usually obtained, but a density rather less than that obtained with a single 50 second exposure.

The wavelength of the exposing light, and the intensity, the emulsion type, and the duration of the intermittent periods of light and dark all have some influence on this effect.

Kostinsky effect

In stellar photography it has been shown that if the images of two stars are close enough on the negative for the halation areas to touch or overlap then the halos are smaller along the line which joins their centres. As a consequence the centres of neighbouring star images seem to be slightly further apart. The effect is more noticeable as the exposure is increased.

This effect is explained as follows: During development potassium bromide is liberated together with oxidation products of the developer, and this retards the progress of development. If as the case here, these retarding substances concentrate along the points of contact of the two discs which are heavily exposed, the result is that the haloes surrounding them are not developed as much here as elsewhere where the developer is more rapidly replenished and darkens the discs unimpeded. The Kostinsky effect comes equally into play with adjacent narrow lines, e.g. in spectroscopic exposures. Here, as well as in astronomical work, it can cause errors in measurements.

Lainer effect

If the emulsion layer is treated with potassium bromide solution or if this is added to the developer then the first appearance of the image is much accelerated, particularly when the total development time is shortened. From this results: 1. A reduction in the 'induction' time. 2. An increase in the Watkins factor. This effect is only of use with developers with a low reduction potential, viz. hydroquinone. The concentration giving maximum effect is 1/10,000.

Nyblin effect

(Probably related to the Sabattier effect.)
A reversal, usually only partial, of the image can be produced when a film which is not sensitive to red is over-exposed and then developed for a long time in red light.

Ross effect

With development in certain developers such as pyrocatechin it is found that heavily darkened zones after drying lie below the general surface. This effect is most noticeable with areas about 5 mm. in diameter, where irradiation is largely compensated for by the refraction.

This is explained as follows. The gelatine of areas that are heavily developed is tanned by the oxidation products of the developer that are released there and cause it to contract strongly on drying.

Russell effect

Photographic emulsions can be fogged by the presence of a number of substances such as resins, varnish, ether, etc. This effect has been attributed to traces of peroxides, produced by slow oxidation of these substances in the air. Keep a watch on new plateholders and cupboards or apparatus that has been recently varnished.

Sabattier effect (or pseudo-solarization)

When a negative (or a positive) which has been partly developed is exposed to white light, more especially to daylight, it may be completely or partially reversed to a positive (or a negative). The reversal first occurs in the least heavily exposed areas. A complete reversal is only produced by excessively heavy second exposure. The reversal is very quick. This effect does not always take place. There has to be a certain relationship between the two exposures. If you wish to make use of the Sabattier effect to produce this kind of image – so-called solarized – you will have to carry out some tests to discover the relative values of the two exposures required.

Schwarzschild effect

According to the reciprocity law of Bunsen and Roscoe equal blackening should be produced by equal amounts of exposure as defined by equal products of the intensity (I) multiplied by the time of exposure (t), at least on the straight line portion of the curve. Schwarzschild in 1899 remarked that this law was only approximately correct. It can be shown that silver bromide reacts less as the luminous intensity is decreased. If the intensity is reduced and simultaneously the duration of exposure is increased to compensate for this reduction so that the product $I \times t$ remains constant the blackening is reduced. An intensity of, say, 100 ft./candles for 1 second gives a far heavier density than 1 ft./candle for 100 seconds.

Put another way, if a certain negative received an exposure of 1 second at $f/4 \cdot 5$ the laws of optics would say that an exposure of 50 seconds is required at $f/32$. In practice to obtain the same densities it might very well be necessary to give 80 seconds.

Solarization

When the exposure given exceeds a certain level then the negative will reverse to a positive. This effect may cause the sun to appear in a landscape negative not as a black circle but completely transparent.

Sterry effect

The contrast of a bromide print can be reduced by immersing it after exposure in a 1–2% solution of potassium bichromate before development. The print should be placed directly into the developer without rinsing.

This effect is mainly made use of to produce normal prints from negatives that are so hard that they give prints that are too contrasty even on extra soft paper. The potassium bichromate reduces the blackening in the shadows and this reduces the contrast.

A. Boer recommends the use of a 1% solution of ammonium persulphate instead of potassium bichromate. This has the advantage that no increase in exposure is necessary as is needed with bichromate.

It is far better wherever possible to use a softer grade of paper.

IV. BIBLIOGRAPHY

Below is given a list of books on photography. To make it easier to find the information you require the list is divided into a number of headings arranged by author's name in alphabetical order.

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V. INDEX

A — ALPHABETICAL LIST OF SUBJECTS, ETC.

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